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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CIX.—No. 2834.] *LONDON: FRIDAY, APRIL 23, 1920.* [*Registered at the General Post Office as a Newspaper.*] PRICE... 1s. 2d. BY FOREIGN POST... 1s. 5½d.

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See Full Page Advt., page 86, April 2.

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See Advertisement page 88. 9402

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See half-page Advertisement page 93, April 16.

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All communications to— H. W. RHID, General Secretary. Head Offices— 81, High Holborn London, W.C.1.

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Engineers are Invited to

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THE FIRST GENERAL MEETING of Prospective Members will be held at the CENTRAL HALL, WESTMINSTER (Committee Room B) ON TUESDAY, APRIL 27th, 1920, at Seven o'clock.

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MAY 6th—PAYMENT BY RESULTS. Aims and Comparison of Systems.
MAY 13th—PRODUCTION ESTIMATING. Ascertainment of Output possibilities.
MAY 20th—PROCESS EFFICIENCY I. Initial Considerations of Workshop Organization.
MAY 27th—PROCESS EFFICIENCY II. Choice of Methods and Tools.
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JUNE 10th—RATEFIXING II. Examples: Engineering, Machining and Fitting, Sheet Metal Work, Paper Slitting, Fabric Work, &c.
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JUNE 22nd—JOB RATE ADJUSTMENTS. Workers' Complaints, Effect of Improved Methods.

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TENDERS.

AUCKLAND HARBOUR BOARD, NEW ZEALAND.

Tenders are Invited for the

CONSTRUCTION and SUPPLY of Five 1 Ton ELECTRIC CAPSTANS and SPARES for same.

Specifications and Drawings can be obtained on payment of a deposit of Two Guineas at the Office of the Board's Agents, Messrs. W. AND A. MCARTHUR, LTD., 18-19, Silk Street, Cripplegate, London, E.C. 2.

Tenders to reach Auckland by noon, on September 1st, 1920. F 725

COUNTY BOROUGH OF ST. HELENS.

REFUSE DESTRUCTOR, PARR DEPOT.

The Corporation of St. Helens are prepared to receive

Schemes and Tenders for the

ERECTION of a REFUSE DESTRUCTOR, together with all contingent works at the Parr Depot within the Borough.

Drawings, Conditions of Contract, and Specifications with Form of Tender may be obtained at the office of Mr. ARTHUR W. BRADLEY, M.Inst.C.E., the Borough Engineer, on payment of £2, which sum will be returned on receipt of a bona fide Tender.

Tenders endorsed "Tender for Refuse Destructor, Parr Depot," and addressed "Chairman of the Health Committee, per the Borough Engineer. Town Hall, St. Helens," must be delivered on or before the 29th May next.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. H. ANDREW. Town Clerk.

Town Hall, St. Helens April, 1920. F 813

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (PLANT AND MACHINERY SECTION).

For Sale by Tender.

SIX PETROL STORAGE TANKS, Horizontal Boiler Type, Siemens Martin Steel riveted plates, ¼ in. thick (built to Admiralty Specification). Dimensions, 9 ft. dia., 30 ft. long. Fitted with manholes, ventilations. 2 in. G.M. Stop Valve, and C.I. Brackets and about 1650 feet 2 in. C.I. Oil Main—as it lies.

Two of these Tanks are lying on the Muirtown Wharf, South of Muirtown Bridge, Inverness, and

Four Tanks and 1650 ft. of Piping are on Admiralty Property near Admiralty Bridge, Nigg, Scotland.

Arrangements can be made for purchasers to obtain tenancy of the sites on which these installations stand.

Full particulars and Tender Forms may be obtained on application to the CONTROLLER, Plant and Machinery Section, Charing Cross Embankment Buildings, London, W.C. 2.

Reference, Gen. 2265.

Tenders close at Ten a.m., on 5th May next.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s., post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W.1. F 805

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MINISTRY OF MUNITIONS.

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FOR SALE BY TENDER.

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M.K. 21389.—One STEEL BOILER TANK, 38 ft. long by 7 ft. dia., with two valves.
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M.K. 21384.—One STEEL BOILER TANK, 38 ft. long by 7 ft. 6 in. dia., with two valves.
M.K. 21385.—One STEEL BOILER TANK, 38 ft. long by 8 ft. dia., with two valves.
M.K. 21386.—Three STONE ACID STORAGE CISTERNS, composed of 5 in. Stone flags, bolted together with iron bolts. Internal dimensions 6 ft. by 6 ft. by 5 ft. deep, lined with 4½ in. acid brick wall.

Used for Acid Storage.

Lying at BROOKE'S CHEMICALS, LTD., LIGHTCLIFFE WORKS, Halifax.

Closing date for Tenders, Saturday, May 15th.

Application for Tender Forms, etc., should be made to the CONTROLLER, Plant and Machinery Section, Disposal Board, Ministry of Munitions, Charing Cross Buildings, Embankment, W.C. 2. Telephone—Gerrard 540, Ext. 143. Telegrams—"Mapiadis, Wire London."

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 16

Tenders for Boundary Marks

REQUIRED by the Survey Department of Egypt in 1920-21.

Tenders will be received up to Noon, May 18th, at the Office of Sir A. L. WEBB, K.C.M.G., Queen Anne's Chambers, Broadway, Westminster, S.W.1, for the Supply of—

150,000 Boundary Marks, each to consist of C.I. Pile Foot and Head, with M.I. Head Cap connected by 1½ in. wire cable or ¾ in. rod.
Also
100 Lever Bars for turning tube.
100 Tube Keys.
100 Keys for pile head cap.
100 Keys for top of cap.

Tender Forms and Blue Prints can be obtained from the above office. G 91

CITY OF LINCOLN.

The Lincoln Corporation invite

Tenders for the Supply,

DELIVERY and ERECTION of the following PLANT for the St. Swithin's Power Station:—

SECTION I. COAL HANDLING PLANT.

Specifications and other particulars may be obtained by manufacturers on application to the Consulting Engineers, Messrs. PREECE, CARDEW and RIDER, 8, Queen Anne's Gate, Westminster, S.W.1.

Copies of the Specifications can be seen at the Office of the City Electrical Engineer, MR. STANLEY CLEGG, Brayford Lincoln.

Tenders upon the prescribed forms must be delivered at the Town Clerk's Office, Guildhall, Lincoln, not later than 11 o'clock on Monday, 24th May, 1920.

An official receipt must be obtained for any tender delivered by hand. Tenders sent by post must be registered.

The council do not bind themselves to accept the lowest or any Tender. G 78

RICHMOND MAIN SEWERAGE BOARD.

CONTRACT FOR STORES.

The Board are prepared to receive

Tenders for the Supply and

Delivery to their Works during the year ending May 31st, 1921, of the following STORES:—

Steam Coal.
House Coal.
Coke.
Grey Lime.
Buxton Lime.
Sewage Precipitants.
Jute Press Cloth.

Specifications and particulars may be inspected from 10 a.m. to 4 p.m. at the Office of Mr. William Fairley, M.Inst.C.E., Engineer to the Board, West Hall Road, Kew Gardens, where also Forms of Tenders may be obtained.

Sealed Tenders, on the forms provided, to be delivered to the undersigned on or before Tuesday, May 11th, 1920.

The Board do not bind themselves to accept the lowest or any Tender.

J. LESLIE G. POWELL, Clerk to the Board.

The Sessions House, Richmond, Surrey, 14th April, 1920. F 971

For Sale by Tender, the Coal

HANDLING PLANT at Belvedere Wharf, Southampton.

Plant Comprises:—

Two BOILER TANKS, about 80 ft. long by 5 ft. 6 in. diameter.
Two Babcock & Wilcox WATER TUBE STEAM BOILERS, each with 1827 sq. ft. heating surface and superheater.
One HORIZONTAL DUPLEX D. A. STEAM PUMP.
One INJECTOR and PIPE FITTINGS.
Main Steam Pipes in Boiler House.
COAL BUCKET, RUNNER BAR and FIXINGS, with lifting blocks and chains.
Two STEAM GENERATING SETS, each comprising Vertical Compound Engine with Cylinders 10 in. by 17 in. by 12 in. stroke. ELECTRICAL GENERATOR, 110 volts, 640 amps., 230 revs., direct coupled on one base plate, by Mather & Platt.
SWITCH PANEL and FITTINGS.

HAULAGE GEAR, Comprising:—

30 B.HP. Motor Spare Armature, Switch Panel and Fittings, Two Sets of Spur reducing Gear, Two friction Drums, Two Rope Pulleys on heavy steel girder framing.
TENSION FRAME and Gear.
SHIP'S STEAM WINCH, Cylinders 8 in. by 12 in. stroke, Double geared with wire Hauling Rope.

HYDRAULIC PLANT, Comprising:—

ELECTRIC MOTOR, 2½ B.HP., 110 volts, 1300 r.p.m.
THREE-THROW PUMP, with 2½ in. rams, worm reducing Gear.
C.I. Box Stands on large base plate.
Switch Gear.
HYDRAULIC ACCUMULATOR, 8 in. ram, with about 5 ft. lift and seven C.I. ring weights.
COAL HOIST and TIP GEAR to lift a Railway Wagon and 12 ton of Coal about 44 ft. high. Steel framing. Top staging ELECTRIC MOTOR, 50 B.HP., 110 volts, 600 r.p.m. Reducing Gear. Spare Armature.
FLOATING PONTOON STAGE, 100 ft. long by 31 ft. wide, supported on 10 steel rivetted Tanks, each about 19 ft. long by 8 ft. by 8 ft.
Horizontal, Vertical and Diagonal Rolled Steel Joist Framing.
Timber Flooring.
Corrugated Sheet Iron Walls and Roof.
One spare Timber built Pontoon Tank.
Coal Conveyor, 7 ft. wide by about 78 ft. effective length enclosed in steel casing.
Top and Bottom Rollers, Hinged Steel Carrying Plates. Adjusting Gear, Balance weights and framing at tail end.
ELECTRIC MOTOR, 30 B.HP., 110 volt, 600-800 r.p.m.
Switch Gear.
Two Countershafts, pulleys and fixings.
One 20 ton RAILWAY WAGON WEIGHING MACHINE, with Plate 12 ft. long, by Polley.
Two HAULAGE TROLLEYS.

Tenders for the purchase of the whole or any of the items to be sent to JOHN GATER, Esq., West End, Southampton, not later than 10th May, 1920, from whom cards to view may be obtained. F 990

BOROUGH OF WIMBLEDON.

ELECTRICITY DEPARTMENT.

STEAM GRAB CRANE

Tenders are Invited for the

SUPPLY of a STEAM GRAB CRANE (Locomotive type). Particulars of requirements may be obtained on application to the undersigned.

H. TOMLINSON-LEE, Chief Electrical Engineer. Corporation Electricity Works, Durnsford Road, Wimbledon, S.W. 19. April, 1920. F 980

ROTHERHAM CORPORATION.

LANCASHIRE BOILERS FOR SALE.

The above Corporation invite

Offers for Seven Lancashire

BOILERS, 30 ft. by 8 ft., in excellent condition of a working pressure of 160 lbs. gauge; fitted with Bennis Stokers. Also TWO GREEN'S ECONOMISERS in connection with same.

Complete lay-out of steam and feed piping and valves available if required.

Full particulars can be obtained on application to the ENGINEER and MANAGER, Corporation Electricity Works, Rotherham. G 81

APPOINTMENTS OPEN.

MINISTRY OF LABOUR—TRAINING DEPARTMENT.

KEIGHLEY TECHNICAL INSTITUTE.

Applications are Invited

for the POST of PRINCIPAL of the Mechanical Engineering Training Centre, which is to be established in the above School for the purpose of training disabled men.

The commencing salary will be £400 per annum.

Details of duties and further particulars may be obtained from the undersigned.

JAMES GRAHAM, Divisional Director of Training. Education Offices, Leeds. G 4

HULL MUNICIPAL TECHNICAL COLLEGE.

Principal—T. LUXTON, B.A., B.Sc. (London).

Wanted at an Early Date a

HEAD of the ENGINEERING DEPARTMENT (Mechanical, Civil and Electrical).

Salary, £300 per annum, to be increased by annual increments of £30 to £600 per annum. Additional payment will be made for Evening Classes.

A schedule of duties and application forms, which should be returned not later than the 5th May, can be obtained on application to the undersigned.

J. T. RILEY, D.Sc, Director of Education. Education Offices, Albion Street, Hull. 19th April, 1920. G 30

PROPOSED TECHNICAL SCHOOL AT JAMSHEDPUR (SAKCHI), INDIA.

Applications are Invited for

the PRINCIPALSHIP of a Technical School to be established at Jamshedpur, India. The Principal will be expected to advise the governing body of the School upon the lines which it is to be developed. The School is intended for the training of apprentices with a view to their becoming foremen in the Works of the Tata Iron and Steel Company and associated Companies in the neighbourhood.

Salary Rs. 1500 per mensem, rising by annual increments of Rs. 100 to Rs. 2000. Agreement for five years. Four month's leave on full pay after full three years' service. First-class passage out and home at commencement of and end of service. The Principal will be required to commence his duties in India during October, 1920.

Applications should be received not later than 8th May, by the under-named, from whom further particulars can be obtained by letter only, marked "Technical School," addressed to the MANAGING DIRECTOR, TATA LIMITED, Capel House, 62, New Broad Street, E.C. 2. F 941

EAST INDIAN RAILWAY COMPANY.

THREE ASSISTANT CARRIAGE AND WAGON SUPERINTENDENTS.

The Directors of the above Company are prepared to receive

Applications by letter only,

from duly qualified candidates for appointment as Assistant Carriage and Wagon Superintendents.

Candidates should be about 25 years of age, and must have had a good general and technical education. Preference will be given to those who have served either pupilage or apprenticeship in the Carriage and Wagon workshops of a British Railway or Railway Carriage and Wagon Builder, and have also had running experience on a railway, but applications will also be entertained from men who have had a locomotive training, and subsequently some experience of Carriage and Wagon work, and preference will be given to men who have passed the Associate Membership examination of the Institute of Civil Engineers, or who hold an exempting degree, but in any case, men must have had a good technical education.

Salary: commencing at Rs. 380 and rising by annual increments of Rs. 40 up to the maximum of Rs. 100 per calendar month.

Terms: A four years' agreement, with first class free passage to India.

The selected candidates will be required to pass a medical examination by the Company's Consulting Physician before appointment.

Applications, accompanied by particulars of the candidate's career in chronological order, together with copies (not originals) of testimonials and a medical certificate of fitness for residence in India (which will not be returned) should be addressed to the undersigned not later than Saturday the 8th of May, 1920.

By order, G. E. LILLIE, Secretary. 28/30, Nicholas Lane, London, E.C. 4. G 21

SOME RESULTS OF SMALL PROFITS IN MANUFACTURING TRADES.

By Frederic Strickland.

In all the various discussions on the question of wages, taxes and profits in the manufacturing trades there are several practical points which appear to have been largely overlooked by those taking part in such discussions. It seems to be assumed by many people that the whole of both wages and profits are spent by the recipients in selfish enjoyment, and that the only question is what proportion should be so spent by those who provide the brains, organisation and capital on the one hand, and those who do the manual work on the other. Hence it has been taken for granted that if the profits of manufacturing trades were reduced by increases of wages it would necessarily be a permanent advantage to the working classes; or, alternatively, that if they were reduced by increases of taxation it would be a permanent advantage to the revenue. Three points appear to have escaped the notice of these people. Firstly, that we need a constantly increasing amount of capital in our industries. Secondly, that when profits are high a large proportion of them is saved and reinvested to extend industries. Thirdly, that capital is easily movable and will go where the best returns are to be obtained.

We want a constantly and rapidly increasing amount of capital in our industries for the following reasons: (1) Because it is the only way to provide for an increasing population; (2) because manufacturing plant is constantly being improved and made more expensive, and it therefore takes more capital to employ each man; (3) because a large part of our industrial population can only be employed by the investment of fresh capital. As for the first and second of these reasons, the facts are fairly evident. The only way to employ an increasing population is by the erection of larger or more numerous factories, and this obviously needs an increase of capital. Again, it is very obvious that as plant becomes more efficient and at the same time more complicated, it becomes more expensive. It also increases the output of each man employed. If plenty of capital is available this, of course, increases both the rates of wages and the number of people employed, for the cheaper production at once creates a greater demand. If no increase of capital is available, however, each improvement will actually reduce the number of people employed. It is quite evident that the modern machine tools, for instance, are far more efficient than the older types, and that if we did not have modern machine tools we should be quite unable to compete with other countries which possess them. It is also, as just stated, evident that, as the modern machine tools have got more efficient they have also become more expensive, and therefore more capital is required for each man employed. This is especially the case where automatic machines are used. For these two reasons alone, therefore, we must have a constantly-increasing amount of capital invested in our industries, or else we cannot keep the whole of our population employed.

The last of the three reasons above mentioned is, however, quite as serious a point, and is very often quite ignored. If fresh capital is not put into industry fresh plant will not be required, and the various works which live by making plant will not get full employment. In every business there has to be a certain amount of money spent every year on the repair and renewal of the plant if the business is to continue. Obviously plant will not last for ever, and it will not last at all without a certain amount of repair. If the capital in the business is kept stationary this needful repair and renewal work will be done, but no more. This would give a certain amount of work to the concerns supplying and repairing such plant, but it is quite certain that this would not anything like keep our various manufacturing concerns going.

Take the shipbuilding trade, for instance. A certain amount of shipping is lost at sea every year and a certain amount is scrapped from old age. With stationary capital this would be replaced, but nothing beyond it would be built, and this would mean that our shipyards would not be turning out more than at the outside a third of the number of vessels they usually do. Consequently only a third of the number of men would be employed.

The same is true of the majority of our engineering industries. Thus if the textile industry had no fresh capital put into it a great proportion of the works which make textile machinery would have very little work to do. The makers of engines and boilers used to drive the mills would also be short of work, and so would the builders by whom the mills are built and those supplying the materials of construction.

The machine-tool trade is certainly one which depends for its employment almost entirely on fresh capital being invested. We might go on with the list indefinitely, and it would be surprising to find what a number of trades in England are dependent entirely on the investment of fresh capital for their continued existence. In this connection it must, of course, always be remembered that the fact of one trade being slack makes others slack also. Thus if fewer ships are built less steel is required, and if less steel is made less coal is wanted, and so on.

Further, a great deal of this works in a circle. The very fact of certain of the engineering trades being slack will mean that men are out of employment and have less money to spend, as will also the various shopkeepers, &c., who serve them. This will in due course mean less demand for the various things these people want and will react on the engineering trades, which live to a certain extent on providing for their wants and amusements, and will make them still slacker. In fact, the complete stoppage of the investment of fresh capital, or even its serious restriction, would cause a slackness of trade, working in a vicious circle, which would be far beyond any slack trade period we have ever had, or we may hope we ever actually shall have.

Now if it is necessary to have constantly-increasing capital invested, where is this capital to come from? This brings us to the second point, namely, that when considerable profits are made a great part of them is saved to be reinvested. There are only two sources from which fresh capital can come: (1) From abroad; (2) from the savings out of income made by people in this country. With regard to the first source no capital will be invested in this country from abroad unless the return on it is greater than that which can be obtained abroad. Obviously, therefore, we shall not get any from this source unless profits are good, and if they are good we can provide the necessary capital from the savings out of our own profits, and so avoid our industries getting into the control of foreign capitalists. Now in practice a reduction in profits means a reduction in the amount saved quite out of proportion to the reduction in the profits. This is because when people invest money they do not reckon to save a certain percentage of their income as a rule, but to save the greater part of the balance after a certain percentage.

Thus we may take the case of a limited company having various profits in different years. The tendency will be to pay a dividend which is a fair percentage on the capital in any case, and even to pay this out of accumulated profits if it is not earned in any one year. If, however, there is a very good year, the whole of the profits are usually not paid out in dividends, but a substantial proportion of them is saved and used to extend the business. This is where much of the fresh capital needed for the continued employment of our population has so far come from. Thus, if such a concern makes a profit equal to, say, 5 per cent. to 6 per cent. on its capital, the whole is usually paid out in dividends. If it makes an amount equal to, say, 15 per cent. on its capital, quite a third will usually be kept in the business to extend it while if it makes less than 5 per cent. on any one year it is quite likely that some of the accumulated capital will be used to pay a dividend with. If the business is only making small profits there is, of course, no inducement to enlarge it, so all profits are paid out as dividends.

Similarly, if dividends much over 5 per cent. are paid the recipients will, in most cases, save and invest a good part, and if industries are profitable they invest in them. If, on the other hand, they only receive an amount equal to what is fixed interest rate, most people spend practically all of it, or if they are of the saving sort invest in fixed interest securities, probably abroad. So we see that unless industries pay on the average substantially greater rates of interest than can be obtained in fixed interest securities, people will cease to invest money in them, and in this case the whole engineering trades will only be very partially employed. If such a state of affairs became permanent we should rapidly cease to be a manufacturing country, and a very large part of our population would have to emigrate in order to get work.

It cannot be too often emphasised that capital is simply saved out of income, and has been so since the first man made his first club. Further, that the greater part of the capital existing in England to-day has been saved in the last 100 years, very largely by people who started with no more than the ordinary working man. It is a fallacy of certain people that when the world was created a certain amount of capital was created also and given to some class called "capitalists" whose descendants hold it now. This is, of course, utter nonsense. Capital consists of factories, mills, tools, mines railways, farms, cleared and fenced land, &c., hardly any of which existed even a thousand years ago, and by far the greater part of which has been accumulated in the last 100 years. Moreover, it is very certain that the greater part of the industrial capital of to-day is in the hands of people whose ancestors 100 years ago had little capital except their clothes and household furniture.

It is, further, a very great mistake to think that capital is all in the hands of very few people. As a matter of fact the majority of large concerns are an aggregate of capital belonging to a great many people. When we hear that a company has made profits amounting to hundreds of thousands of pounds, we must remember that this sum is shared among a very large number of people, many of whom only get a few pounds each as their dividend.

It is very important to remember this, and also to remember that if any working man thinks that any trade is making vast profits he can share those profits by investing money in it even if he has only a very small amount of money to invest, for companies are constantly being formed, and they usually have their capital in 1*l.* shares. It is a very great pity that more working men do not do this, though they might not find that the profits were quite so gigantic as they seem apt to imagine. It seems as if the trades unions might help this a great deal by some scheme for advancing money for working men to take up shares in companies on some plan which enabled them to pay for them by weekly instalments.

There is another very serious point to consider, and that is that capital is much more easily moved than some people seem to realise. No doubt unimaginative people think when there is talk about capital moving that what is meant is the pulling down of, let us say, a mill or factory and the rebuilding of it somewhere else. Well, even this may be done in some cases, though usually it would probably hardly be worth while. This is, however, not the usual way in which capital shifts. What actually happens is that the old plant is allowed to wear out and no new plant is put up.

In every business run on sound lines a considerable amount of money is put aside for the repair and renewal of plant before profits are counted. If the business is sufficiently prosperous to be worth carrying on continuously this money is, of course, as we have already stated, spent from year to year in repairs and renewals. If, however, the business is not worth carrying on where it is, this money is not spent in this way, but is spent on putting up new plant somewhere else.

How quickly the whole of the capital in a trade could be shifted in this way it is difficult to say, but taking ordinary engineering plant all round it probably requires quite 10 per cent. of its capital value to be expended in repairs and renewals. If this be so then 10 per cent. of the capital could be shifted each year, the same proportion of the hands being thrown out of work. In practice, this would

not often be done, as what would happen would be that something less than 10 per cent. of the older plant would be scrapped in place of being renewed and this would at once cause want of employment. Wages would then fall and the profits on the less obsolete plant would temporarily go up, and so it would be kept going a bit longer.

That a whole trade can shift in this way, however, is shown by the history of the Thames shipbuilding, which once was a flourishing business including several large firms employing quite a number of hands. It is now practically extinct as the capital has migrated to other places where the money can be more profitably employed.

There is yet another point which should be very carefully considered by those who think that no industries should pay profits of any serious amount, and that is the effect on the brains of the country. We are often told, even by those who propose to practically tax capital out of existence, that they want to encourage the use of the best brains in the country. They omit to remark that people who really have brains usually earn and save a very considerable amount of money. In fact, the essential object a clever man has in doing his best is usually to save money for himself in his old age and for his family after him. There is, therefore, no object in a clever man remaining in a country where it is impossible for him to get a good return from his money when he has saved it. There is no difference to the saving man between taxing an earned income and taxing the interest on the savings out of earned income. The object of saving is to get an income from the savings, and if a greater income can be got out of a certain amount of capital in one country than in another, that is the place where clever men, on the whole, will go to. It does not matter whether the low return is due to the wages being to high in proportion to the production or to heavy income taxes. The point is that what is required by the class of man we are referring to is a good return on his savings.

The whole question is, as we have said, well worth the careful study of those interested in economic questions, especially those interested in the welfare of labour. For a good many years before the war the tendency was for capital to be continuously more and more handicapped in this country by taxation of various forms and by restrictions of output, &c. The result was that more and more capital was being invested abroad every year. Some people favour the export of capital on the ground that it takes the form of manufactured goods and therefore gives employment at home. In a few cases this may be so, but even then there seems no reason why it is better to make plant for export than plant for home use. If a man, for instance, puts up a cotton mill abroad, he no doubt exports a good deal of the machinery. If he put up the mill in this country, however, he would employ just as many people making the machinery for home use as he does for export, while the mill when it was built would employ people here in place of giving employment abroad. The greater part of the capital invested abroad, however, is *not* in the form of manufactured goods. Even in the case of the cotton mill, for instance, the building is not exported ready made. Railway embankments and tunnels are not exported ready made, nor are mines. The fact is that a great deal of the capital expended on the establishment of any industry or undertaking is spent on the spot and the rest is spent on plant, which is bought wherever it is cheapest and best. Often this has been either America or Germany.

The amount of capital which was being sent abroad before the war every working day appears to have exceeded half a million. This is a very great amount, and if even half this had been invested in this country, it would have meant an enormous increase in employment, more manufacturing, greater exports or fewer imports, and a better revenue without extra taxation. It would have provided employment for many men who, as things were emigrated. Had investment in this country been encouraged for some years before the war, we should have started the war with far greater resources than we had and it would therefore have been easier to win it, while we should not have had to import such an enormous amount of articles and the exchange would not now have been so much against us.

Further, before the war we were ceasing to be a manufacturing nation in the sense we had been 50 years before, but were getting to be more and more a nation of traders and speculators. There is always plenty of opportunity for the employment of capital in the latter pursuits, and if it pays better to so deal with it than to use it for manufacturing this practice will increase. The practice is, however, very unsound from the national point of view, and especially from that of labour.

The matter is really essentially in the hands of labour. If our artizans like to make manufacturing profitable, plenty of capital will be provided, and there will be good employment all round. It is mainly a question of output and taxation. If, on the other hand, they prefer to have restrictions on output and heavy taxation of capital, then people either will not save the necessary capital for the maintenance of our industries, or if they do save, will invest their capital abroad. It is often said that the British capitalist is "unenterprising" because he does not put his capital into English enterprises and develop English inventions, &c. The real fact is, however, that he is extremely enterprising and therefore puts his capital where it gives him the best return.

THE DIELECTRIC CONSTANT OF GASES AT LOW TEMPERATURES.

The capacity of an electric condenser depends upon the medium separating the plates of the condenser, and the specific inductive capacity or dielectric constant of an insulating material is defined as the ratio of the capacity of a condenser immersed in that medium, to the capacity which the same condenser would have in air, or more strictly speaking, in a vacuum. The dielectric constants of gases differ little from unit value, so that air can be taken as unity. Boltzmann found, in 1875, the following values: Air 1·000590, hydrogen 1·000264, CO_2 1·000996, CO 1·000690. Liquids and solids give much higher values: Solid paraffin about 2, ebonite 3, various glasses 6 to 8, petroleum 2, castor oil 4·75, ether 4·75, ethyl alcohol 26·5, amyl alcohol 15, water 75 at 25 deg. C. and 90 at 3 deg.

On Maxwell's electromagnetic theory the dielectric constant is the ratio of electric strain to stress, and the square root of the dielectric constant k, *i.e.*, $\sqrt{k}$, should numerically be equal to the refractive index for long waves. That equality holds with remarkable accuracy for gases even for waves of the moderate length of sodium D light; in other cases extrapolations to invisible long waves may have to be made. In the case of gases the k should be connected with the actual volume occupied by the molecules and the mean free path of the molecules, as Clausius pointed out when laying down the foundations of the kinetic theory of gases, and according to the law of Clausius-Mossotti the expression $\frac{k-1}{k+2}\cdot\frac{1}{\rho}$, where ρ is the density of the gas, should be a constant. That this ratio is constant in the case of air for pressures up to 340 atmospheres was proved by Occhialini and Bodareu (Pisa) in 1912; their mean value for k was 1·000585, very much like that of Boltzmann. But recent experiments on the change of k with temperature—the ratio became smaller as the temperature rises—did not seem to accord with the Clausius-Mossotti law, even on the H. A. Lorentz conception of a dielectric.

According to this view dielectrics contain electrons like conductors; but the electrons are not free to move; they are held by quasi-elastic forces and can only be shifted from their rest-positions by electrostatic forces. To get over the temperature difficulty Debye suggested some years ago that there were in a dielectric, in addition to the displaceable electrons, dipoles already formed (not only formed by placing the dielectric in an electric field), and this suggestion was tested by Boguslawski, by Czukor, and—last year—by Jona (*Physikalische Zeitschrift*, January, 1919). The most recent experiments were made by Hans Riegger in Danzig, but had to be given up under present conditions (*Annalen der Physik*, vol. lix, pages 753 to 760).

The capacity measurements of Riegger are made by the method of Mandelstam. There are two loosely-coupled oscillating circuits I and II; I is excited by quenched sparks; the oscillations act on II, the circuit of which comprises three condensers, the first for taking determinations by means of a dynamometer, the other two for tuning. The plates of the first condenser are placed within a sealed vessel which is first evacuated, and the capacity of the condenser is thus determined in *vacuo*. The vessel is then filled with the gas in question and the capacity is redetermined. The whole vessel is lowered into a large Dewar flask. The gases experimented with were air at a temperature of — 185·5 deg. C., hydrogen at — 191 deg., methane at — 154 deg., carbon dioxide at — 72 deg., and carbon monoxide at — 189 deg. Observations taken at pressures of 200 mm., 400 mm., 600 mm. and 760 mm. of mercury respectively gave, in the case of air, the following values for $k-1$: 0·000502, 0·001002, 0·001472, 0·001887. No irregularity was observed at these low temperatures and various pressures except in the case of carbon monoxide; in the case of the other gases the experiments did not confirm Debye's assumption of the existence of dipoles.

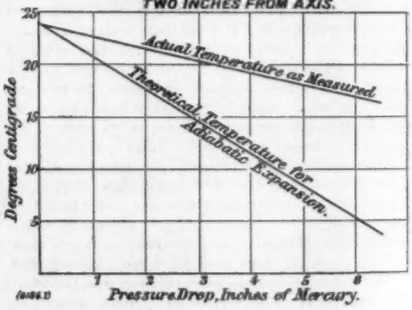
STUDY OF FLIGHT VORTICES.

By F. W. Caldwell and E. N. Fales.

(*Concluded from page* 504.)

Principles of the Writers' Method of Visualising Air Flow.—In the tunnel previously described it is seen that certain novel characteristics obtain not heretofore usual in similar apparatus. The writers' method of visualising air flow utilises certain of these novel characteristics. It depends upon the fact that the moisture in the air condenses out as fog when the temperature is reduced to the dew-point, provided there is a solid or liquid nucleus to start

Fig. 10. TEMPERATURE AT THROAT OF AIR FLOW IN WIND TUNNEL, MEASURED TWO INCHES FROM AXIS.



the condensation. In the McCook-Field wind tunnel the temperature drop is brought about through adiabatic expansion of the air during acceleration due to 100 in. of water suction. Relative humidity of the atmosphere can be artificially raised, if too low, by means of water or steam. The necessary nucleus for condensation is provided by the model itself.

The temperature of the air passing through the throat is calculated on the assumption that expansion is adiabatic from atmospheric pressure to pressure corresponding to condensation, and is polytropic below the latter pressure.* Correct knowledge of throat temperature is, of course, essential and it is necessary to develop a special method of thermometry for reading it. Present methods are inapplicable to its direct measurement, for a thermometer introduced into the airstream occasions more or less adiabatic compression of the air striking it, with consequent rise of temperature at the point of impact. (See chart, Fig. 10.) The most advantageous position for the thermometer is with the bulb down-stream, where it is subject chiefly to

* For an excellent paper by Dr. Otto Neuhoff, on the "Adiabatic Changes of Condition of Moist Air and their Determination by Numerical and Graphical Methods," see "Smithsonian Miscellaneous Collections," vol. li, No. 4, 1910.

skin friction rather than impact; further investigations are being made of the matter.

Flight vortices become readily visible by this method and can be photographed with the aid of a searchlight. Fig. 12 is an enlargement of a moving picture film looking down-stream. It is inferior to visual observation, since the vortices seem to be below the model, due to perspective. To the naked eye they are in line with the wing tips, and are clean-cut, perfect circles. They extend down-stream a distance of several dozen chord lengths from the rear corner of each wing tip, enlarging after moving about, lose themselves in the general confusion. In a diagonal view they have the appearance of long foggy fibres, stretching down the tunnel like wooden mouldings; the axes of whirl are, of course, parallel to the tunnel axis. Under proper humidity and lighting conditions the whole become a beautiful iridescent sight, violet and purple hue predominating.

Use of the Writers' Method Jointly with Balance Readings for Analysis of Aerodynamic Flight.—Three charts of lift coefficients, Figs. 13, 14 and 15, are included in this article for the purpose of identifying various flow regimes with changes in K_y. It may be well to give a brief outline here of former experiments bearing on discontinuity of flow about bodies in a stream of moving air. Numerous experiments have been made with models of symmetrical shapes, and less extensive researches have been carried out with aerofoils. O. Föppl, and also Melville Jones, made tests on the air resistance of cylindrical wires, and found the resistance coefficient decreased at high values of $\frac{VL}{\nu}$. Föppl's work suggested the existence of discontinuity, such that his values of R plotted against $\frac{VL}{\nu}$ could not be drawn as continuous curves.

In testing the air resistance of spheres, G. Eiffel showed a decided discontinuity to exist when certain velocities were reached, the critical speed coming earlier for larger spheres. ("Comptes Rendus de l'Académie des Sciences," du 30 Décembre, 1912.) Maurain verified the results ("Bulletin de l'Institut Aerotechnique de l'Université de Paris," Fasc. IV, 1913). Tests had previously been made by Costanzi in a water basin ("Rendi Conti, Stabilimento di Esperienzi e Construzioni Aeronautiche del Genio," Anno II, No. 4, October 31, 1912). His results, though not conclusive, were significant in comparison with those of Eiffel and Maurain, after account had been taken of the difference in kinematic viscosity of air and water. C. Wieselberger corroborated the discontinuity of air flow past a sphere, but found a higher critical value of $\frac{VD}{\nu}$ than did Eiffel and Maurain ("Zeitschrift für Flugtechnik and Motorluftschiffahrt," May 16, 1914). Prandtl explained the discrepancy in terms of turbulence in the boundary layer of air flowing past the sphere. He showed that the honeycomb in Eiffel's tunnel was capable of producing such turbulence. ("Nachrichten der Königlichen Gesellschaft der Wissenschaften tier Göttingen Math-Physicalische Klasse," 1914.)

As regards aerofoils, Mr. Orville Wright showed the effect of this sort of discontinuity within the range of practical flight. O. Föppl had early shown the effect in a plate at angles of incidence from 38 deg. to 40 deg. ("Jahrbuch der Motorluftschiff Studiengesellschaft," vol. iv, 1910–11). His results were, however, outside the range of flight angles. Mr. Wright conducted, in 1918, a particularly interesting series of experiments, the results of which have, unfortunately, not been published, wherein new discoveries were brought out regarding discontinuity of flow about propeller sections. He found that, at certain angles, thick sections manifested a dual value of the coefficients, the angle at which discontinuity occurred depending on whether the angle was increasing or decreasing at the time when the readings were taken. Throughout the range of instability, the high lift value always corresponded to a low drift value, and *vice versa*. It was possible to make the values change back and forth between the two points at will by disturbing the air current. Using smoke lines as well as fine silk threads, Mr. Wright demonstrated that the transition was accompanied by a distinct change of flow. He had previously, in 1913, observed an analagous behaviour of hydroplanes in water.

The writers have been able to verify conclusively the change of flow about aerofoils brought to their attention by Mr. Wright and to make visible the change from one vortex formation to another of a distinctly different type. In these experiments, wherever discontinuity has been encountered it has always been found that the drag and lift became discontinuous simultaneously, and that the high value of lift always coincided with the low value of drag, and the low value of lift always coincided with the high value of drag.

Existence of Two Critical Speeds for Aerofoils.—One of the novel and significant features of the experiments has been the discovery of a second critical speed for aerofoils, as well as a first critical speed analagous to that obtaining in the case of geometrical shapes (Fig. 15). Early in the course

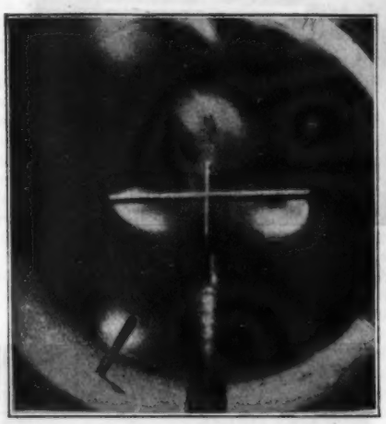


FIG. 11. VIEW LOOKING DOWNSTREAM ALONG TUNNEL AXIS. NOTE TENDENCY TOWARD MERGING OF DISTURBANCES DUE TO CENTRE SUPPORT AND TUNNEL WALLS.

FIG. 12. PART OF THE DISTURBANCE DUE TO WIND TUNNEL WALLS IS SHOWN AT UPPER PART OF CIRCUMFERENCE.

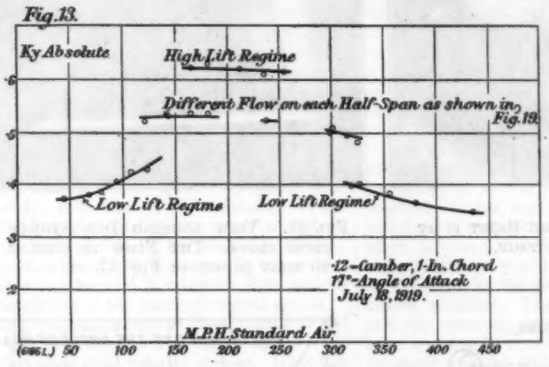
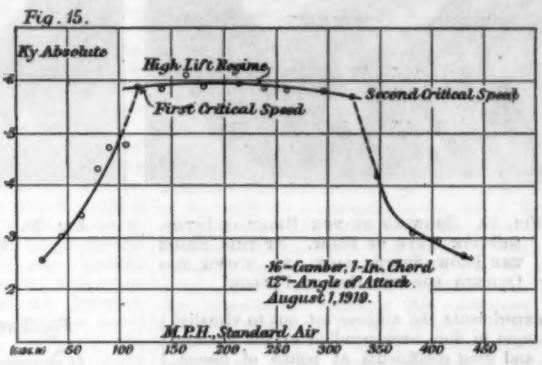
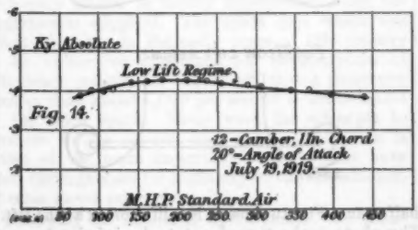


Fig. 13.
Ky Absolute
High Lift Regime
Different Flow on each Half-Span as shown in Fig. 19.
Low Lift Regime
Low Lift Regime
12-Camber, 1-In. Chord
17°-Angle of Attack
July 18, 1919.
M.P.H. Standard Air
(m.p.s.) 50 100 150 200 250 300 350 400 450





their diameter as the distance increases. The shape, size, and direction can be noted, but the periodic run is so rapid that it requires stroboscopic analysis. For corroboration of the phenomenon at slow speeds, smoke lines are useful, a special apparatus for the purpose having been developed. The observed vortices differ for different aerofoil set-ups.

Visualisation of Unobstructed Air Flow.—When the model is removed the vortices and eddies of flow through the unobstructed throat may be observed. The condensation is more pronounced behind the impact tube and thermometer bulb than elsewhere, since these are obstacles to the flow, and therefore constitute nuclei for condensation. A projecting cotter-pin, $\frac{1}{4}$ in. high, at the wall, causes a perfect vortex, not visible in the illustration, which shows up against the white foggy background as a black circle. Figs. 11 and 12 show the tunnel flow partially, at the upper part of the circumference.

The general appearance of the air flow, which may be considered typical of all air flow, is as follows: a cross-section at the throat shows a seething mass of fog spectres, denser at the walls than at the centre, though occasionally the entire disc fills up with fog to the point of opaqueness. The spectres have, in the cross-sectional plane, a gentle movement like the flame of an alcohol stove, showing the constant readjustment of equilibrium. Vortices and S-shaped whirls continually form, and,

STUDY OF FLIGHT VORTICES.

FIG. 16. HIGH-LIFT VORTEX ON THE RIGHT.

FIG. 17. HIGHER SPEED THAN FIG. 16. ON THE LEFT THE VORTEX IS APPROACHING THE UNSTABLE STATE.

FIG. 18. FURTHER DEVELOPMENT IN THE TRANSITION FROM HIGH TO LOW LIFT REGIME.

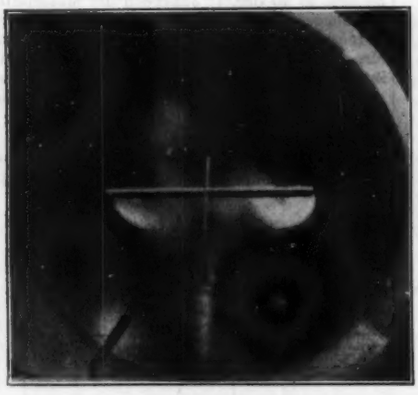


FIG. 19. SHOWING ON THE RIGHT AN INTERMEDIATE TYPE OF FLOW. AT THIS STAGE THE FLOW SHIFTS BACK AND FORTH TOO QUICKLY FOR THE EYE TO FOLLOW.

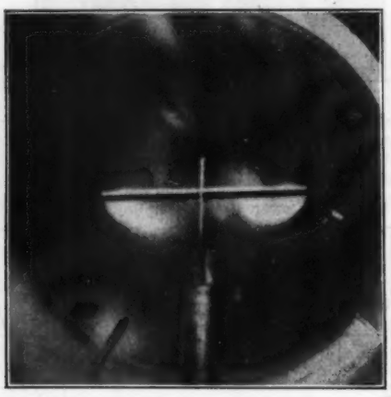


FIG. 20. FLOW AT THE RIGHT IS AT TRANSITION STAGE.

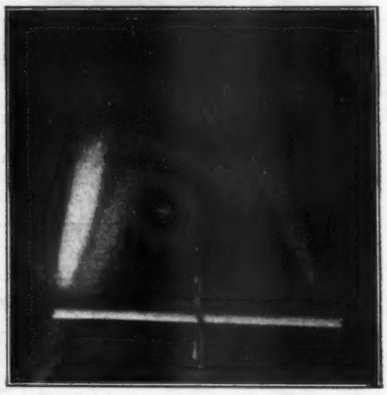
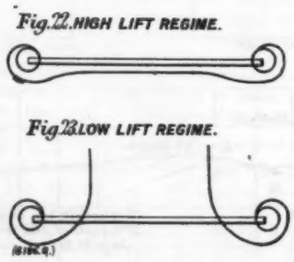


FIG. 21. VIEW LOOKING DOWNSTREAM FROM ABOVE. THE FLOW IS SIMILAR TO THAT SHOWN IN FIG. 17.

of the experiments the authors set out to visualise the changes in flow corresponding to the changes in lift and drag coefficients at points of discontinuity. t was possible to observe very clearly the changes in flow occurring at the point of discontinuity corresponding to the second critical speed, and the nature of the change is described below. At the first critical speed where discontinuity occurs the authors were limited to smoke and powder methods of making observations, and their efforts to photograph the vortex formations at the lower speeds were therefore unsuccessful. The discontinuity resulting from speed and angle changes was manifest in all the aerofoils tested. The models covered a range of thickness varying from a camber ratio of 8 in 100 to 20 in 100. Discontinuity was not found in the thinnest sections when set at the smaller positive angles. It is thought, however, that it would be so found if the speed were sufficiently increased.

The effect on coefficients produced by the change in flow is enormous, as may be seen by reference to Figs. 13, 14 and 15, showing the lift coefficient as a function of the velocity. Fig. 15 shows the two critical speeds, Fig. 14 shows the low regime of lift. The character of the general vortex phenomena accompanying the K_y drop at the second critical speed undergoes a remarkable change. The photographs Figs. 16 to 21 were made with a moving-picture camera in an attempt to record the two types of flow, and should be compared with Figs. 13 to 15. Fig. 16 shows a high-lift vortex at the right-hand half-span; Fig. 19 shows a low-lift vortex at the left. The photographs turned out to be inferior to eye observations, however, and are supplemented with a brief verbal description. In the high-lift regime the general shape of the fog-spectre, seen from the mouth of the wind tunnel, is like a trough whose floor (edge vortex sheet) slopes downward from the trailing edge, and whose walls (tip vortices) are increasingly high as the distance down-stream increases. The cross-section is roughly like a shallow letter "U." At higher speeds, however, the low-lift regime prevails, and the observed phenomenon is suddenly altered. Following out the above homely analogy, we may imagine that the walls of the trough remain substantially as before; the floor, however, splits longitudinally and curls upward, extending the two limbs, now free, to a point well above the tip vortices. Figs. 22 and 23



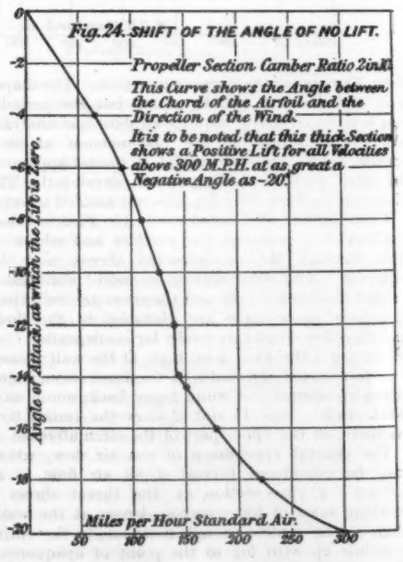


Fig.24. SHIFT OF THE ANGLE OF NO LIFT.
Propeller Section Camber Ratio 2in1.
This Curve shows the Angle between the Chord of the Airfoil and the Direction of the Wind.
It is to be noted that this thick Section shows a Positive Lift for all Velocities above 300 M.P.H. at as great a Negative Angle as -20°
Angle of Attack at which the Lift is Zero.
Miles per Hour Standard Air.
0
-2
-4
-6
-8
-12
-16
-20
50
100
150
200
250
300

are sketches intended to represent the respective shapes, as they stand out when viewed with the eye. The transition from high-lift to intermediate

type of flow is shown best at the right tip in Figs. 16 to 20. Fig. 21 is a diagonal view of the unstable condition of Fig. 17.

An interesting variation of the flight vortex is furnished by replacing the aerofoil with a flat disc normal to the wind. Here the fog surface is formed as a streamline converging toward a point half a dozen chord lengths down stream.

Application of these Results to Propeller Problems.—When the critical speed at which the change in flow takes place is reached, there is, in some cases, a violent chattering of the model and support and the nature of the vibrations readily suggests a connection with the fluttering sometimes observed in propellers. The speed encountered is equal to the tip speed of slow-speed propellers, but is considerably inferior to the tip speed of the very large fast-turning propellers used on the Liberty engine. Many static tests carried out by the writers on propellers have shown an effect which appears to be related to the discoveries made during the series of aerofoil experiments. It is well known that the ratio of propeller thrust to propeller torque must be independent of speed of revolution if both thrust and torque are proportional to the square of the revolutions. It has been found in practice, however, that the ratio of thrust to torque decreases greatly with revolution speed when high tip speeds are reached, and that it sometimes shows a rapid decrease accompanied by violent fluttering. The analogy to the results of the aerofoil tests is obvious, and it is felt that considerable study is desirable in order to connect these facts in a rational manner. We have found by practical experience that, if we do not go below a value of V/N D of 0·65, we get a very fair propeller efficiency. As we have gradually increased the speed of our planes we have gone on increasing the revolutions per minute of the engine and the diameter of our propellers, so that the value of V/N D has remained about the same for the great majority of propellers in actual service.

The authors have always assumed that there was no limit to this development, apart from the characteristics of the plane and engine; that is, the assumption has been made that the propeller speed could be doubled as soon as it was possible to double the plane speed and strengthen the engine enough to stand the stresses involved. It now appears, however, as though there is a limit to propeller speed apart from the value of V/N D or, to use more familiar terms, apart from pitch ratio. Unfortunately, even the speed obtainable in the McCook-Field wind tunnel is not great enough to measure the limiting velocity for relatively thin sections when set at low angles, consequently the authors are only able to infer that it exists for thin sections from extrapolation of the curve of critical speeds.

Regarding the significance of these results to the propeller designer, attention is called to the shift of the no-lift angle with velocity change. This fact has not heretofore been demonstrated, and is not well-known among engineers. Fig. 24 shows this shift for a section of 0·2 camber. All the sections tested showed the shift to a less degree. It is to be noted that a section which, at low speed and negative angle, shows negative lift, may at high speed exert a positive lift at an angle as low as minus 20 deg. During an increase of velocity the angular position of the resultant force vector changes from the quadrant of negative lift to the quadrant of positive lift.

LITERATURE.

Telephony without Wires. By PHILIP R. COURSEY, B.Sc.(Eng.), A.M.I.E.E. London: The Wireless Press, Limited. Henrietta-street, Strand, W.C. 2. [Price 15*s.* net.]

THE improvement in wireless telegraphy and telephony, the achievement of the past and the hopes of the future, are subjects in which the general public is very closely interested, and the books in which experts explain the mechanism that has successfully surmounted the difficulties of yesterday, or indicate the prospects for to-morrow, will be readily acclaimed. The degree of curiosity to be satisfied will vary greatly and therefore a similar variety will characterise the information supplied. In this work, the author has considered, technically, the art of transmitting intelligence electrically, and he shows how the work of the scientist and the electrical engineer, by following definitely recognised principles has resulted in improving the mechanism that when established on a commercial basis, ministers so greatly to the needs of the public. He does not convey or conceal his information in the abstruse symbols in which mathematicians revel, nor is he writing for beginners, who have not learnt the language, or the conventions of the electrician. Herein he is justified, no one ought to begin the study of electrical phenomena by endeavouring to master the principles that have guided its latest development.

In addressing students who are familiar with electrical practice, Mr. Coursey is able to dispense with those chapters on rudimentary principles, which are to be found in every elementary text-book on the subject, but are a wearisome surplusage to many. In their place is substituted a welcome historical account of the early attempts to transmit intelligence by conduction and induction, methods as employed by Preece and others, and which still find occasional practical application in mining operations, where, owing to the absence of high voltages, sparks, &c., greater safety is promoted in dangerous localities. Photophones and thermophones that utilised radiant light and heat as the transmitting medium seemed to offer a prospect of success, and considerable ingenuity was shown in devising a suitable form of apparatus, but the range of communication was necessarily so limited that however interesting scientifically, it failed to attract commercial enterprise, and many instances prove that while theory or *a priori* considerations suggest a possible line of advance, the physical and mechanical developments necessary for success have followed as a direct result of commercial or traffic operations. When the range of transmission is limited to a few hundred yards, there is little to attract capital or excite imagination. The selenium cell has perhaps not received the attention its sensitiveness deserved. It might have been used for other purposes than transmitting sound, for it has the power not only of detecting very feeble illumination, but will give indications of minute changes in a sensible illumination, features that make it the most sensitive photometer in use.

As soon as Morse signals were received aurally by wireless telegraphy, a hope was entertained that the transmission of articulate speech by electromagnetic waves might be accomplished, making commercial radiotelephony feasible. It was recognised, however, that though wireless telegraphy and radiotelephony would involve the same medium of transmission, the problems presented were by no means identical. The reasons for this difference and the direction in which these problems would have to be solved are adequately explained. The necessity and the difficulty of increasing the spark frequency should be clearly apprehended from the explanation supplied. The spark gap, which was much in vogue in the early years of this century is an ineffective apparatus for the purposes of telephony, mainly for the reason that a frequency greater than about 1,000 per second is unattainable in the open spark. Many were the attempts to produce better results, and a full description is given of the more important varieties that have been distinguished for ingenuity or the introduction of some novel principle.

Following an historical development, the possibilities of the quenched spark gap come under review, and the degree of success that has attended generic variations in design is demonstrated. The object sought was to substitute for the intermittent groups of rapidly-decadent waves, a succession of continuous electromagnetic waves. Success was apparently within reach, especially in small-scale apparatus, but with heavy currents required for long-distance transmission, progress was not so marked. A great step in advance was made when the Poulson arc generator came into operation, and the influence of hydrogen or coal-gas in increasing the steepness of the volt-ampere curve was fully recognised. Then frequencies of the order of 250,000 were attained, and the solution of the commercial problem seemed in sight. This discovery constituted a critical point in the history of the development and might have been placed more saliently. The importance of the innovation is diminished by the prominence given to many forms of arc oscillation generator, of which the Poulsen apparatus constitutes the original type.

The description of the Edison effect in glow lamps, due to the flow of a current between the positive terminal of the filament and a metal plate sealed in the bulb, serves to introduce the class of vacuum oscillation generators, whose various forms are all traceable to the original Fleming valve detector, as costly lawsuits have satisfactorily determined. Its distinguishing characteristic is the unidirectional flow of electricity from an incandescent filament to a surrounding metal cylinder within the bulb, when this cylinder is at a higher potential than the filament. If a perforated plate or wire grid is placed between the filament and the metal plate, we have the general design of the audion and in this form is best adapted for the generation of electric oscillations. The action of the generator is analogous to that of the humming telephone, which emits a musical note when feeble vibrations set up in the microphone diaphragm vary the current through the telephone receiver, and the sound emitted keeps the transmitter diaphragm in motion. The author devotes many pages to the description of various forms of vacuum generators in use, but the near future will see many more adapted or invented. War experience has demonstrated that the use of the general principle will be widely extended.

In whatever way more or less continuous electric waves are radiated from the transmitting station, we are still far from conveying articulate speech. It remains to explain how this frequency energy can be modulated in accordance with speech waves, and be made available for receiving the spoken word at the other end. This problem has become increasingly difficult of solution with the development of the modern high power oscillation generators, which apparently are necessary for communication over long distances. Fortunately, as the author shows, the required control and modulation are proportionately less difficult than in the old spark-gap method, where far less energy was employed. The governing principle is simple enough, but the details are sufficiently puzzling, though the author's illustrations and notation assist the text very materially. It is evident that the movement of a diaphragm of some form of carbon microphone, inserted in the aerial circuit, will vary the amplitude of the radiated continuous waves, and if the diaphragm is moved by speech waves the amplitude will be altered in accordance with the wave form of the speaker's voice. The proposition can be stated simply, but in practice the difficulties are many. For long-distance speaking the continuous wave radiation represents 100 h.p. or more. The variation of amplitude must be effected through a microphone which passes perhaps 10 amperes. There is very great dissipation of energy and the overall efficiency of the station will be low. Much of the energy disappears in heat, and this leads to the introduction of water-cooled microphones, liquid microphones and a host of devices. To overcome each difficulty, not one, but many remedies are suggested, though these may not differ generically. The author has described many designs and illustrated various types of microphones, but he has probably not exhausted the schemes that have been put forward as promising success. Any one of these may be superseded by the discovery of to-morrow, for the problem has attracted a large number of investigators and the reward of a successful solution will be large. Mr. Coursey's summary is valuable. The influence of successive increments to the accumulated experience is clearly detailed and cannot but be informative, but when he reviews the whole effect of what has been achieved in the control of this radiated energy it is impossible to mistake a note of disappointment. He contends that the problem of microphonic control of large amounts of high-frequency energy has been attacked in an unsystematic manner, "with very few really quantitative determinations of the utility, efficiency, or other factors connected with the instruments and their field of usefulness and limitations."

The final step in the achievement of wireless telephony is to render the speech audible at the

receiving station. The whole battery of apparatus used in wireless telegraphy is at the command of the operator and is fairly familiar. Crystals and electrolytic detectors are giving way to valves, audions, and the heterodyne receiver. Some form of valve type is likely to be generally employed, and, indeed, in long-distance experiments in radio-telephony, the pre-eminence of such apparatus is assured. The object to be effected is to rectify the continuous high-frequency oscillations in the receiving current, in such a way that the variations in amplitude impressed by the microphone in the transmitter circuit, should reappear in the rectified current passing through the telephone, making the sounds of the voice addressed to the transmitting microphone audible. The heterodyne valve receiver, producing "beats" between two sets of oscillations of slightly different frequencies, has commendable features and many supporters, who delight to vary its form while retaining its principle, the number of possible circuit arrangements being practically unlimited. Not amplification, but simplicity is needed, however, and this quality at present seems best assured in the Fleming valve or thermionic detector.

It is not unimportant to inquire what is the immediate field of usefulness for long-distance wireless telephony. The imagination is, of course, excited by the successful transmission of speech from New York to San Francisco, or from Arlington to Paris, and the accomplishment of impossible feats is confidently predicted. But at present such experiments, however successful, have little commercial value. For overland work, there is little field for competition with the old established and more private wire telephone, unless its installation should prove cheaper and its maintenance less than the heavy charges involved in the expensive apparatus used in long-distance lines. Through tropical jungles and unoccupied territory radio-telephony may prove a valuable asset, and where the maintenance of a wire is troublesome wireless will find its opportunity, but long distance transmission would scarcely be necessary in such a case. Aircraft will probably command its use as a luxury, as passengers on liners utilise wireless telegraphy, but the superiority of speech over the Morse code in such cases is not very pronounced. A more hopeful outlook arises in competition with submarine cables, for, as at present constructed, speech transmission over these is quite impossible for long distances. Wireless transmission of speech may suffer from attenuation with distance, but not from distortion, and in this respect is at a great advantage over cablework. On the other hand, land lines, when available, can be used for speech in both directions with equal ease. Changing over from speaking to receiving offers no difficulty, but in wireless this change is troublesome, and no successful duplexing of the wireless gear under all circumstances has yet been satisfactorily effected.

Land Drainage, from Field to Sea. By C. H. J. CLAYTON, M.S.E., A.M.I.Mech.E., Chief Drainage Engineer to the Board of Agriculture and Fisheries, with a Preface by the Right Hon. Sir AILWYN FELLOWES, K.C.V.O., K.B.E., Past-President of the Board of Agriculture and Fisheries. London: Offices of *Country Life*. [Price 6*s.* net.]

NEGLECTED drainage resulting in the increase of waterlogged and unproductive lands, impairing the quality of the soil and consequently entailing diminished crops, is one of the insidious causes of impoverishment that has been too long overlooked by the statesman and disregarded by the economist. If a fire had swept through the country destroying every farm-house in its path, the loss to the entire community would not have been greater than that which has actually resulted from the preventible damage due to failure to provide and maintain an efficient drainage system. The spectacular view of a burning barn rivets attention upon a definite and sudden loss, but the picturesque sight of a stream choked with a cheerful abundance of weeds and the flow of water delayed by every variety of vegetation, arouses no thought or regret of the economic loss of which its stagnant waters may be the cause.

Will Mr. Clayton's book arouse us to a keener sense of fitness and make us see in a proper light the consequences of a carelessness, or in some instances it may be of a selfishness, that has reduced the fertility of many acres of valuable land and made us not only more dependent on foreign assistance, but by long custom, more willing to lean on that frail support? On various grounds he is in a position to speak with authority. He was secretary of a Departmental Commission appointed in 1913 to investigate the causes of recurrent floods, and subsequently, when under the Defence of the Realm Regulations, steps were taken to bring more land under cultivation, Mr. Clayton reported on some 200 cases in 32 counties in which it was thought that immediate works might be carried out under the emergency powers conferred under the Act. His experience is therefore wide. He has not only seen the land, but heard the comments of those who cultivate it, and his deliberate opinion is not lightly to be set aside. His book is written as much as a warning as a guide. He does not propose to instruct the experienced hydraulic engineer, but he does hope that the information supplied will be of use to officers and members of Drainage Boards, Commissions of Sewers, County Drainage Committees, agents and agriculturists generally, enabling them to understand better the systems and to appreciate the need for efficiency in the mechanism they control or with which they are concerned. In these days, land is changing hands rapidly, a new set of proprietors is taking the place of the old-established county families, and this change promises to bring more enterprise in schemes designed to improve the value of newly-acquired property. It is to this class that the book should prove of the greatest use, written as it is in an untechnical manner, but in such a way as to stimulate effort and to make owners appreciate the need of adopting measures that will restore fertility to exhausted and derelict land.

Few dwellers in cities can know the lengths to which neglect of precautions had imperilled the productiveness of the soil. The difficulties that farmers had to encounter in endeavouring to bring a larger area under the plough in order to increase food production were not appreciated at the time, and probably have been forgotten since. But Mr. Clayton states that the view of farmers was unanimous in insisting on the necessity of freeing their farms of surplus water, if the full quota of land scheduled for corn production was to be brought under cultivation. Much of the land was waterlogged or the saturation of level was within about 18 in. of the surface. Grass might grow under such conditions, but the fertility of the land for food producing purposes was practically destroyed, since deep-rooting plants cannot possibly thrive on a soil, the interstices of which are filled with water. The removal of excess water was a problem of no common difficulty, and explains many of the objections that were raised to breaking up grass land. If any other evidence were needed it is supplied by Sir Ailwyn Fellowes who, writing with the authority of an ex-President of the Board of Agriculture, states that the Executive Committee appointed to take the necessary measures to increase food production "were compelled by their local knowledge, and as a result of the surveys they conducted, to report that large acreages were unable to make their proper contribution to the food supply of the country, because they were saturated or liable to floods."

It is not uninstructive to examine the causes that have led to the deterioration of the drainage arteries in the past or restricted new construction in recent times. The first and main cause is traceable to the want of co-ordination among the controlling authorities, often created to serve private ends, and exercising jurisdiction over very limited areas. Such minute subdivision entailed all the evils of divided responsibility, and provoked all the obstacles that conflicting interests could raise. In more modern times, agriculture has been regarded as a decadent industry, overwhelmed by the ever-increasing demands of manufacturing interests, and the preservation of cultivable land has not been considered a valuable national asset. Local and contracted views adopted by a close association of landlords and agents could not but be prejudicial to large schemes, whose operations to be beneficial must extend to the sea. A method of drainage that passed the excess of water to neighbouring lands, simply and selfishly transferring the burden from a higher to a lower level within a limited area, must be universally condemned. But those who had charge of the upper reaches of rivers cared little for the inconvenience they occasioned elsewhere, and more disinterested views could be expected only by enlarging the area of control. The House of Lords, more than forty years ago, were fully alive to the evil, and suggested as a remedy for the neglected state of several important streams and the maintenance of good conditions in others, that each catchment area should be placed under a single body of conservators, who should be responsible for maintaining the river from its source to its outfall in an efficient state. This was a counsel of perfection, because each stream supported numerous committees, each regarding its policy as irreproachable and its work as indispensable. The active committees appointed to promote public health, to encourage navigation, to improve land drainage, to advance power schemes and further other objects of public utility, could not but view with disapproval the advent of superior powers, that might supersede their authority or question their administration. Sir A. Fellowes quotes as an instance the River Ouse having a catchment area of about 1,750,000 acres, in which area the governing authorities number nearly 100, "and even then only about half the river and three-fifths of the floodable or waterlogged land is covered."

Conditions have not improved since the Select Committee of the House of Lords on the Conservancy of Rivers issued its report. The care of the waterway has often been separated from the care of the banks. Dredging and embanking have often been under different authorities, effectively preventing improvement of the channel by mechanical means, which can only be effectively achieved by a single authority having complete control of the banks and forelands, as well as of the channel throughout the improvable length. To the local circumstances tending to deterioration we have to add the wider causes, due to the altered condition of trade and the general policy the country has pursued since the repeal of the Corn Laws. The decay of canals and of inland navigation has contributed its share in blocking the fairway of our streams, the substitution of steam for water mills has led to the neglect of mill sluices, weirs and spillways, the strain thrown upon channels and banks in times of flood and from under drainage have all tended to reduce an incomplete and chaotic system to one of complete inutility. Naturally, therefore, when an outcry was raised for increased food production, implying a return, or partial return, to earlier methods of agriculture, the machinery was found out of gear, and the mischief of neglect was revealed by the absence of a satisfactory arterial drainage.

Is there any remedy for past neglect, or is it one that is prohibitive by reason of excessive outlay? Mr. Clayton shows very clearly what has to be done, and that it will be remunerative to undertake. He outlines the process, but does not enter into minute particulars of mechanical operations. Great detail is the more unnecessary because there is no great room for originality or ingenuity in digging a ditch, cutting and removing weeds from rivers, clearing and streams, or repairing embankments. Some German prisoners were usefully employed in such operations, and it is perhaps to be regretted that more were not similarly occupied. Considering the magnitude of the operations the outlay is not excessive, and a satisfactory return is assured. Mr. Clayton expresses his deliberate opinion in asserting "that there is hardly an acre of land that is incapable of being effectively drained, and drained to show a profit." To illustrate the effect of adequate drainage he quotes instances of farms in practically contiguous areas, where the application of efficient drainage has so transformed the land, that excellent pasture or arable on deep rich soil capable of supporting full averages of stock, or of producing valuable root crops, will be found side by side with the coarsest of pasture, foul with rushes and wild iris. In one river valley in Somersetshire, the letting value in one case was 90*s.* to 120*s.* per acre, and in the other only from 15*s.* to 25*s.*, a margin that should serve as sufficient stimulus for concentrated and

collective action. For, let it be remembered, isolated effort is of little effect, the water has ultimately to find its way to the sea, and not to be allowed to cumber and deteriorate land at a lower level.

The addition of the words "From Field to Sea," declares one purpose of the book. It indicates the development of a scheme for utilising the streams and waterways in the country as a whole, and of increasing their value and usefulness. It was necessary to show how neglect and a mistaken policy had impaired their effectiveness and diminished their usefulness; it became further necessary to show how their purpose can be restored or increased, and their work made more efficient. The author writes trenchantly when describing or denouncing the laxity that has permitted the misuse of a ready means for the conveyance of waste water, but he writes encouragingly and instructively when suggesting plans of recovery and outlining the character of the operations for putting these plans in execution. Starting from the sea, he shows that a sound drainage engineering scheme must keep open the main channels to the sea, tidal or otherwise, if that part of the rainfall which is neither infiltrated nor evaporated is to pass harmlessly away. Engineering practice has been too much confined to so-called local improvements, to producing a desired result on particular properties, and overlooking the fact that there can be no thorough or decisive improvement while the main tidal outfall and other natural channels are neglected.

The remarks on coast erosion, the carriage of silt, detritus, &c., are pertinent, and the interference of tidal phenomena generally in preventing the free removal of the volume of land-water is considered with care. Of peculiar importance to the hydraulic engineer is the effect of flood tides in delaying the discharge. Obviously the capacity of any drainage scheme is limited by the number of hours during which the outfall channel permits free passage, and such considerations react upon the calculated levels and the provision of means for conveying water from a specified catchment area. It is also quite evident, that when the outfall ends of pipe drains are submerged, as they may be by the rising of tidal waters in estuaries, the drains not only fail to act, but that river water can enter and pass up to a level, possibly carrying the water on to the lands sought to be drained.

Very useful hints are given on many topics and very much experience is embodied in the chapters on outfall channels, sluices, low-level drainage, and drainage by pumping. The subject of underdrainage is of such importance that it might have been treated in more detail. Of embankments, their construction and preservation, the author writes with very modified approval. In his experience, these expensive structures have been built somewhat recklessly. Improvements in the channel and obvious alternatives might often be substituted with advantage, and afford a considerable saving, while their protection against the ever-present plague of rats and rodents entails constant watchfulness and expense. Moreover, the embankment is liable to give a false sense of security and too often conduces to the neglect of the channel.

We may congratulate the author in presenting a picture of arterial drainage in all its important bearings, and would respectfully join in the hope expressed by Sir A. Fellowes "that the impetus given to land drainage and the livelier appreciation of its necessity aroused by the war, may not be allowed to die."

Hot Bulb Oil Engines and Suitable Vessels. By WALTER POLLOCK, M.I.N.A., M.I.Mar.E., M.I.M.E., M.I.M. London: Constable and Company, Limited. [Price 42s.]

THE particular type of internal-combustion engine utilising oil fuels variously characterised as the hot bulb, surface ignition and semi-Diesel, has within recent years very rapidly come to the front for a variety of duties, not the least important of which is marine propulsion, in cases where small and moderate powers are required. None of the names above quoted are completely satisfactory, but for the types of engines as described in this volume "Hot Bulb" is sufficiently descriptive.

The subject of this review is the first volume to appear which deals exclusively with this relatively new prime mover. This is, in measure, somewhat remarkable, since there are installed now some hundreds of thousands of horse-power, totalling in all to no less than seven figures. Technical contributions to our leading Institutions and journals dealing exclusively and exhaustively with this type of engine are also exceptionally rare. Only one can be recalled. The reason may be sought and an explanation may tentatively be put forward. The hot-bulb engine in its development during the last twenty years, in the latter part of which period, rapid strides have been made, has been of the nature of continual compromise in the endeavour to maintain the maximum of simplicity of design and construction and ease of manipulation coupled with low first cost and reasonable operating expense. Development along such lines and within these limits must of necessity be more governed by practical results than directed by theoretical considerations. Whilst the proto-type of this motor is British in inception, as for instance the Hornsby-Ackroyd and Priestman engines, to Sweden must be given the major portion of the credit of bringing it to its present stage of very considerable commercial application in wide fields of work. The application of these Swedish engines to small craft the world over has very rapidly extended during the last ten years, and Mr. Pollock's work is primarily a record of the more outstanding examples of these installations. British manufacturers, however, are now producing semi-Diesel or hot-bulb engines in large quantities, which are in design and construction in no way inferior to the best on the Continent, and it is to be regretted that so little attention is given in the book under review to home products and that but a few of their salient features and exclusive advantages are mentioned in passing.

As a text book we welcome this volume, because it is perhaps overdue, and is the first to deal with an engineering development likely to grow to great dimensions, but we could have wished that in balance and in method of treatment it were considerably less of a collection of extracts from many makers' catalogues and photographs, and plans of vessels fitted with one Continental make of engine. Such collation, however, serves a purpose of utility as a book of reference.

Whilst it is probably true that the hot-bulb engine has grown step by step and that design is more largely a matter of experience than of calculation and theory, yet there is certainly a great need to explore the theoretical issues in order to assist in applying such simple mechanisms to higher and yet higher powers. There are very many points in connection with the design of the semi-Diesel or hot-bulb engine still to be experimented upon and open to very great improvement. This side of the question is quite ignored in the volume now under notice. To mention but a few of such headings, we might quote efficiency of scavenging, and increasing the power output per unit of cylinder volume, improved means of facilitating starting within a shorter period of time than the 8 minutes to 15 minutes mentioned by Mr. Pollock, capacity to burn satisfactorily a wider range of fuel oils without air injection of the fuel or water drip and other somewhat unsatisfactory expedients. There are further the important qualities of manœuvring capacity, slow running, and so forth. In some of these directions considerable improvements have recently taken place in this country, but of these the author makes no mention.

The most valuable part of this work is undoubtedly that which gives information from experience on the specific subject of fitting hot-bulb oil engines to various and varied types of craft. There is in this section a certain amount of matter which will serve a useful purpose alike to manufacturers who have the marine market in view and to buyers who contemplate installing this type of prime mover.

To judge from the illustrations given in this book the great majority of hot-bulb engines develop considerably less than 80 brake horse-power per cylinder. The largest marine installation mentioned is that of the oil-tanker Bramell Point, of dimensions 306 ft. by 47 ft. by 28 ft., carrying 5,000 tons of cargo and bunker fuel on 22 ft. 8 in. draught. This vessel is fitted with triple screws, each driven by a four-cylinder Bolinder engine of 500 brake horse-power, giving 125 brake horse-power per cylinder. Such an arrangement cannot be regarded as final in any way, the triple screws run at a much higher speed of revolution than can be conducive to maximum propeller efficiency for a vessel of 10½ knots full speed. The fitting of these engines complete with shafting and propellers, for 1,500 brake horse-power total, is probably merely an expedient arising out of war conditions.

In Mr. Pollock's opinion the semi-Diesel or hot-bulb engine is ripe for much higher powers than 125 brake horse-power per cylinder. We think that makers will be well advised, only very gradually, to increase the power above 150 brake horse-power per cylinder and to consolidate carefully each step so made. This book deals almost exclusively with engines and installations of quite small power, 60, 80, 120 and 160 brake horse-power per engine, being the favourite examples. Arguments deduced from such cases do not necessarily apply to powers running into four figures.

Similarly, in the many tables given comparing the cost of oil *versus* steam plants, too favourable a case for the former is generally made out by eager and earnest oil-engine advocates. The savings on a conservative basis are as a rule sufficiently attractive without crediting the oil engine, for instance, with a depreciation rate per cent. of 5 as against 8 in the case of the steam plant. Such can only apply when the steam prime mover is liable rapidly to go out of date, as is perhaps the case with certain types of small craft. The prices taken for such comparisons for solid and liquid fuels are not those which apply to-day, but since these figures are likely to change considerably for some time to come this matter is not one for criticism. The necessary corrections can always be made provided the basis of comparison is equitable. As regards saving in weight and space, the author has drawn comparisons from the smaller type of craft, where the internal-combustion engine shows to its best advantage. The greater the power the less becomes the saving in the direction of space and weight, especially if the propeller efficiency with the oil engine is to be comparable with that obtained when steam power is used.

The type, the illustrations, and the finish of the volume under notice are of a high order. Many of the illustrations and plates, however, are almost duplicates, and appear in certain cases with inadequate descriptions.

BOOKS RECEIVED.

A Text Book on Machine Drawing for Electrical Engineers. Forming an Introductory Treatise on the Construction of Electrical Machinery and Apparatus. By EDWARD BLYTHE, A.M.I.Mech.E., Cambridge: The University Press. [Price 20s. net.]

Coal Mining and the Coal Miners. By H. F. BULMAN, M.I.Min.E., F.G.S. London: Methuen and Co., Limited. [Price 15s. net.]

History of the Great War Based on Official Documents by Direction of the Historical Section of the Committee of Imperial Defence. Naval Operations. Vol. I. *To the Battle of the Falklands, December, 1914.* By Sir JULIAN S. CORBETT. With case of Maps. London: Longmans Green and Co. [Price 17s. 6d. net.]

Elementary Aeronautics, or the Science and Practice of Aerial Machines. By ALBERT P. THURSTON, D.Sc. Second edition, revised. London: Sir Isaac Pitman and Sons, Limited.

Modern Illuminants and Illuminating Engineering. By LEON GASTER and J. S. DOW. Second edition, revised. London: Sir Isaac Pitman and Sons, Limited. [Price 21s. net.]

Fuel Production and Utilisation. By HUGH S. TAYLOR, D.Sc.(Liverpool). London: Baillière, Tindall and Cox. [Price 10s. 6d. net.]

Pitman's Common Commodities and Industries—Electricity its Production and Applications. By REG. E. NEALE. London: Sir Isaac Pitman and Sons, Limited. [Price 2s. 6d. net.]

Laxton's Builders' Price Book, 1920. Originally Compiled by WILLIAM LAXTON. One hundred and third edition. London: Kelly's Directories, Limited. [Price 4s.]

National Benzole—The British Motor Spirit. London: The National Benzole Association, 30, Grosvenor Gardens, S.W. 1. [Price 1s. net.]

Iron and Steel in India. A Chapter from the Life of Jamshedji N. Tata. By LOVAT FRASER. Bombay: *The Times* Press.

Vereinheitlichung in der Industrie. By Dr. GEORG GARBOTZ. Berlin: R. Oldenbourg. [Price 9 marks.]

Cement. By BERTRAM BLOUNT, F.I.C. London: Longmans, Green and Co. [Price 18s. net.]

The Theory and Practice of Aeroplane Design.—By S. J. ANDREWS, B.Sc., and S. F. BENSON, B.Sc. London: Chapman and Hall, Limited. [Price 15s. 6d. net.

THE ARMSTRONG SHIPYARD.

(*Continued from page* 472.)

The most important of the shop buildings in the yard is undoubtedly the platers' shed, which is the largest of its kind in the country. As shown in the key plan, Fig. 1, on page 367 *ante*, the building is situated near the heads of the berths at the southern end of the yard and extends for nearly a quarter of a mile, terminating in front of the main office building. Between the shed and the embankment are the plate racks, which are illustrated in Fig. 109, on Plate XXVIII. This illustration, which was reproduced from a photograph taken from the south-west corner of the yard, also shows the external appearance of the platers' shed. Trucks containing plates are brought down the slope from the North-Eastern Railway line by the yard locomotives, which haul them along the tracks under the gantry shown in Fig. 109. The trucks are here unloaded by two overhead travelling cranes, the plates being sorted according to size and thickness and placed in the appropriate racks. The racks, it may be mentioned, are formed of old rails set in concrete foundations, this cheap and simple construction giving effective support to the plates and enabling them to be easily and quickly inserted and removed. Of the two cranes, only one of which is visible in the illustration, one was designed and constructed by Messrs. Royce, Limited, of Manchester and the other by Messrs. T. Broadbent and Sons, of Huddersfield. They are each capable of lifting a load of 10 tons, and of travelling laterally at the relatively high speed of 200 ft. per minute; the largest plates can thus be easily and expeditiously handled. The crane rails, which are 48 ft. 9 in. above ground level, are supported on one side by the columns of the platers' shed, and at the other side by a special steel gantry, clearly shown in Fig. 109. The total length of the gantry is 1,120 ft. and the span is 76 ft. 6 in. between the centres of the crane rails. Two large pickling tanks are provided near the southern end of the plate racks, as indicated by the small rectangles on the key plan, Fig. 1, on page 367 *ante*.

The platers' shed is a steel-framed structure, 1,200 ft. in length and 150 ft. wide, divided into three bays as shown in the tranverse section, Fig. 118, on page 541. The wing bays, it will be noticed, are each 52 ft. in width, while the central bay is 46 ft. wide. A number of interior views, which convey a good idea of the impressive dimensions of the building, are reproduced in Figs. 110 to 116, on Plates XXVIII to XXXI, accompanying this issue. These views will be referred to in more detail later. The shed is completely closed in on the sides with large sliding doors in convenient positions, so that work can be carried on in comfort in all weathers. The greater part of the roof, and a considerable portion of the sides and ends, are covered with Mellowes' "Eclipse" glazing, while the remainder is covered with corrugated sheets. The arrangement gives ample light in the daytime, as will be gathered from the interior views, and, at night, efficient illumination is provided by means of 2,000 c.p. half-watt lamps. In an upper storey at the northern end of the shed is situated the mould loft, which extends over the eastern wing bay and the central bay. The floor dimensions of the mould loft, which is illustrated in Fig. 117, above, are 320 ft. in length by 98 ft. wide, and the height to the spring of the roof trusses is 18 ft. 9 in., while in the centre the height is 28 ft. The sides and ends are covered with corrugated sheets and Mellowes' glazing, while the roof is partly glazed and partly covered with slates. Special attention was, of course, given to the construction of the floor in order to ensure a perfectly true surface, and, for this reason, specially selected Siberian pine was employed in planks 3 in. wide by 3 in. thick. A series of benches is arranged along the whole length of one side of the loft for making moulds and templates, and the work is further facilitated by the employment of portable motor-driven saws and other tools. The loft is well lighted both by day and by night, and, in cold weather, it is comfortably warmed by means of steam pipes. Leading from the mould loft at the southern end, and extending over the central bay only, is a template store-room measuring 35 ft. by 80 ft. In the original design, it was intended to equip another store-room at the northern end with kitchens, cloak rooms and lavatories, to be used at receptions held in connection with launches and other functions. This provision is, however, unnecessary now that the yard is employed on commercial work. Access to the mould loft is obtained by a staircase 9 ft. wide arranged in three flights, with teak treads.

The structural steelwork for all the shops in the yard was constructed and erected by Messrs. A. and J. Main, Limited, of Glasgow (now Messrs. Armstrongs and Main, Limited), while the foundations for the columns and for the various machine tools were carried out by Messrs. Edmund Nuttall and Co., of Manchester. In the platers' shed alone some 4,200 tons of steel were employed, arranged as shown in the transverse section, Fig. 118, on page 541, and also in Fig. 110, on Plate XXVIII. The columns, which are spaced at 80-ft. intervals so as to give ample room for handling large plates, are composed of two 12-in. by 4 in. by 36·47-lb. channels braced with 3½-in. by 2½-in. by $\frac{5}{16}$-in. angles on both sides. The columns carry longitudinal girders which support the crane tracks and the roof principals, the latter being spaced 20 ft. apart. The longitudinal girders are of the lattice type, 15 ft. 3 in. deep and 3 ft. 3 in. wide, and are divided into six bays. The upper booms consist of two 10-in. by 4-in. by 30·6-lb. channels and the bottom booms of two 10-in. by 3½-in. by 23·55-lb. channels, while the verticals are composed of braced angles, and the diagonal bracing of flats. There are three 10-ton electric overhead travelling cranes in each of the wing bays, as shown in Fig. 114, Plate XXX, and two similar cranes in the central bay, the height of the crane rails above the floor level being 33 ft. 4 in. in each case. These cranes, which were constructed by Messrs. T. Broadbent and Sons, Limited, of Huddersfield, are provided with independent motors for hoisting, traversing and longitudinal travel, the speed of the latter being 250 ft. per minute. This speed, it may be mentioned, has been found as high as convenient in view of the fact that plates up to 45 ft. in length have to be handled. Additional facilities for handling materials are provided by means of a large number of fixed hydraulic and

FIG. 117. THE MOULD LOFT.

hand-operated cranes placed in convenient positions in proximity to the larger machine tools, as shown in the interior views on Plates XXVIII to XXXI. The usual method of handling plates is to lift them from the racks and bring them up to one of the sliding doors of the shed by means of one of the travelling cranes over the plate racks. They are then taken by one of the hydraulic cranes inside the shed to the straightening rolls, if required, and thence by means of the overhead cranes in the shed to the various machine tools. When the necessary operations are completed, the plates are placed on railway trucks and hauled down to the berths by steam locomotives, one of which can be seen in Fig. 112, laying out a ship's deck plating, and it will be noticed that pneumatic drills are employed for drilling the plates in position. It should, perhaps, be explained in connection with this view that the open sides shown have since been filled in as stated above.

The tool equipment of the shed includes a variety of punching and shearing machines disposed as shown in the key plan, Fig. 119. They are designed to punch holes up to 1½ in. in diameter in mild steel plates 1½ in. in thickness, or up to 1¼ in. in diameter in high tensile steel up to 1¼ in. thick. The large punching and shearing machines are by Messrs. Craig and Donald and by machines, &c., which form part of the equipment of all modern platers' sheds, and therefore call for no special comment. General particulars of these are given on the key plan, Fig. 119, below. There are, however, a number of heavy tools and special appliances which are worthy of more detailed treatment. Entering the shed from the northern end, one first notices a set of three radial drills of a special type, one of which is shown on the left of Fig. 112, on Plate XXIX. These drills, which were specially designed by Messrs. William Asquith, Limited, of Halifax, to meet the firm's requirements, consist of a bridge mounted on a pair of rails and carrying a high-speed radial drilling arm. The

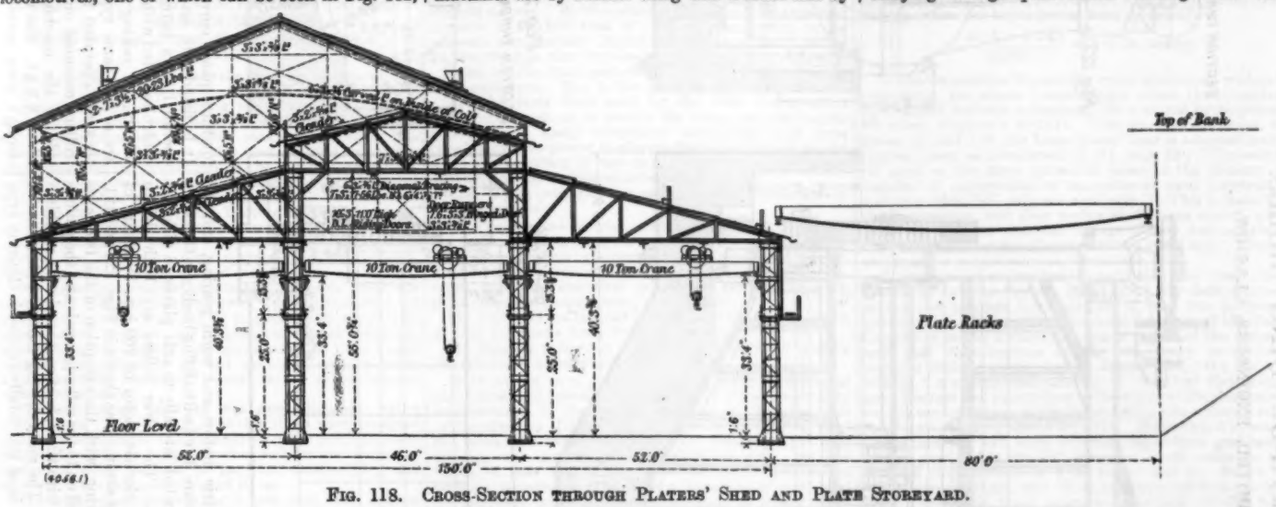


FIG. 118. CROSS-SECTION THROUGH PLATERS' SHED AND PLATE STOREYARD.

Fig. 119.

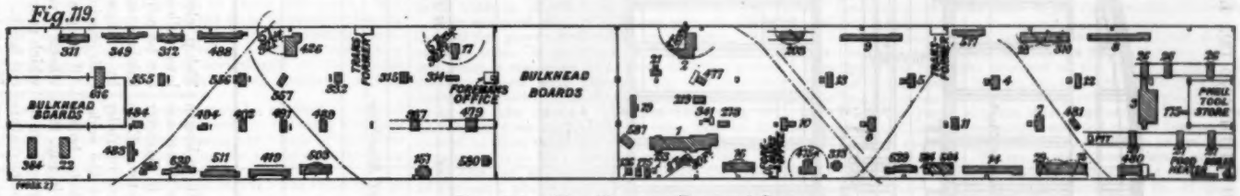


FIG. 119. KEY PLAN OF PLATERS' SHED.

MACHINE TOOLS IN PLATERS' SHED.

1. Plate-bending rolls.
2. Plate-straightening machine.
3. Keel-plate bending machine.
4. Punching and shearing machine.
5. Punching and shearing machine.
6. Double punch.
7. Double punch.
8. Plate-edge planer.
9. Plate-edge planer.
10. Punch, shears and manhole punch.
11. Punching and shearing machine.
12. Punching and shearing machine.
13. Punching and shearing machine.
14. Plate-edge planer.
15. Radial Drill.
16. Radial Drill.
17. Plate-straightening machine.
19. Beam bending, horizontal punching and double angle-cutting machine.
21. Punch and shears with side notcher.
22. Punching and shearing machine.
26. Radial drills on rails.
27. Radial drills on rails.
28. Radial drill.
29. Radial drill.
136. Bar shears.
151. Hydraulic joggler.
153. Grinder.
175. Grindstones.
203. Radial drill.
219. Plate splitter.
273. Cold saw.
310. Radial drill.
311. Radial drill.
312. Radial drill.
313. Punching and shearing machine.
314. Punching and shearing machine.
315. Punching and shearing machine.
332. Punching and shearing machine.
341. Box bed radial drill.
349. Plate-edge planer.
364. Punching and shearing machine
367. Double punch.
402. Punching and shearing machine.
419. Plate-edge planer.
426. Plate-straightening machine.
475. Roller joggling machine.
477. Double punch.
479. Double punch.
480. Plate-bending rolls.
481. Punching and shearing machine.
483. Angle cutter, beam bender, and horizontal punch.
484. Cold saw.
488. Plate-edge planer.
489. Punching and shearing machine.
491. Punching and shearing machine
494. High speed cold saw.
503. Radial drill.
504. Radial drill.
511. Plate-edge planer.
517. Scarfing machine.
555. Double punch.
556. Punch, shears and notcher.
557. Plate-straightening machine.
580. Hydraulic manhole punch.
584. Radial drill.
585. Drill.
587. Band saw.
616. Punching and shearing machine.
629. Scarfing machine.
630. Scarfing machine.

on Plate XXIX. The 'railway' tracks crossing the shed are indicated by chain-dotted lines in the key plan, Fig. 119, above, and the tracks leading to the berths are similarly shown in the general plan of the yard on page 367 *ante*.

The lay-out of the shed is shown in the key plan, Fig. 119, which is accompanied by a list of the principal tools. It will be noticed that the punching and shearing machines and other tools, are arranged with ample space between them so that long plates can be operated on in one machine without interfering with the work at another tool. They are also, of course, arranged so that the various operations can be carried out in an efficient sequence involving the minimum possible amount of handling. In general, it may be remarked, the heavier work is done at the northern end of the shed, i.e., the right-hand portion of Fig. 119, while the southern end is occupied with work of a lighter character. The central portion of the shed, as shown in the key plan, is free from machine tools, this portion being used for the laying out of decks and bulkheads. Fig. 111, on Plate XXIX, illustrates the process of

Messrs. Bennie and Sons, while the smaller ones, capable of working on mild steel plates up to 1 in. in thickness, are by Messrs. Cameron. One of the Craig and Donald machines, that numbered 10 in Fig. 119, is fitted with a manhole punch capable of cutting manholes up to 23 in. by 15 in. in ¾-in. plates, while the machine numbered 21, by Messrs. Cameron, is provided with a notching attachment suitable for working on plates up to ¾ in. thick. All the large punching and shearing machines are provided with 8-ton cranes of 23 ft. rake, while the smaller machines have 5-ton cranes of 20 ft. rake attached. Plate-straightening rolls, or "mangles" as they are termed, are provided of various makes and capacities, the largest, a four-roller machine by Messrs. Craig and Donald, being capable of dealing with plates up to 12 ft. in width and up to 2 in. in thickness. Each mangle is served by a hydraulic crane of suitable capacity—in fact, all machines in which work has to be supported during the machining process are fitted with self-contained cranes.

In addition to the above-mentioned tools there are a number of radial drills, plate-edge planers, joggling plate to be drilled is laid on bearers between the rails, and one, or more, of the three drills is traversed along the rails as the work of drilling proceeds. Another battery of three exactly similar drills is, at present, provided on the other side of the shop, and a third set of rails has now been laid at the southern end of the shed, on to which one drill can be removed from each of the existing batteries; there will then be three sets of rails with two drills on each. We have already illustrated and described these drills in detail on page 521 of our ninety-seventh volume, to which we must refer our readers for further particulars of them, but we may here remark that they have answered their purpose admirably for the extensive drilling work on high-tensile plates used in warship construction during the war. Between the two existing sets of travelling radial drills, as indicated in the key plan, Fig. 119, there is a store-room for portable pneumatic tools, a large number of which are used on the building berths.

One of the most important tools is the large plate-bending rolls situated near the centre of the shed and numbered 1 on the key plan, Fig. 119,

THE ARMSTRONG SHIPYARD: PLATE-BENDING ROLLS.

CONSTRUCTED BY MESSRS. HUGH SMITH AND CO., LIMITED, ENGINEERS, GLASGOW.

Fig. 120.

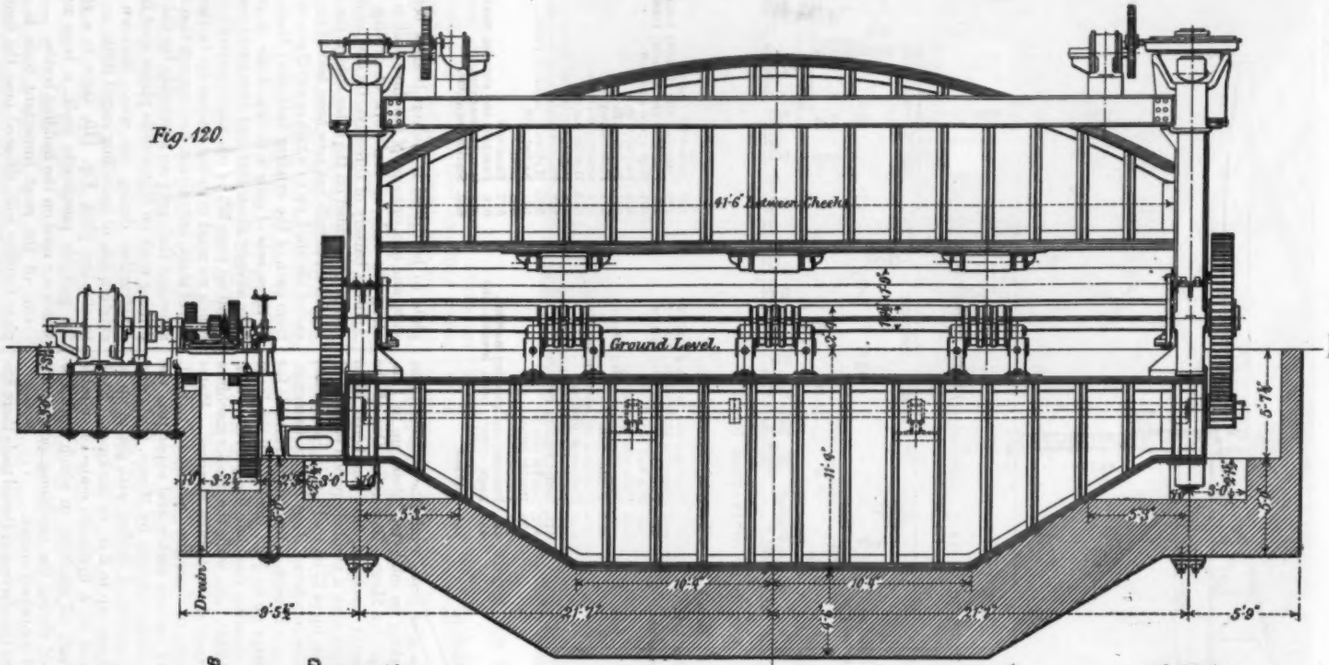
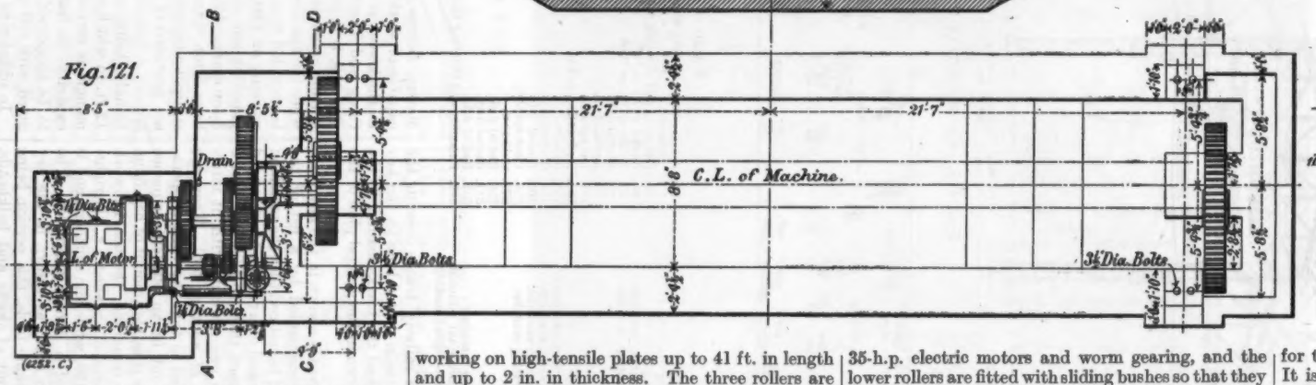


Fig. 121.



SECTION THROUGH FOUNDATION AT C.D.

Fig. 122.

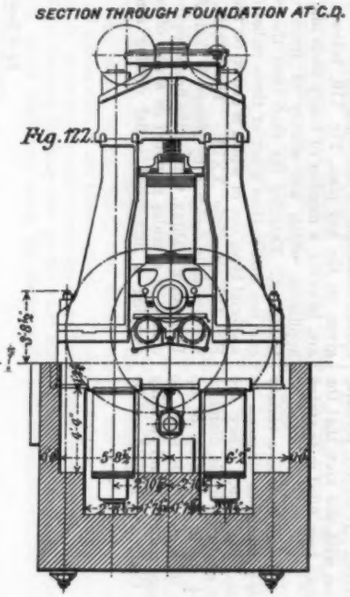
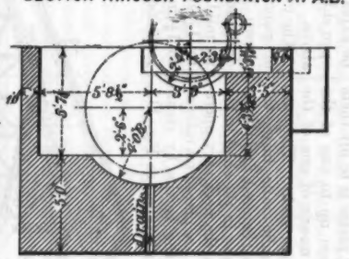


Fig. 123.

SECTION THROUGH FOUNDATION AT A.B.



page 541. This tool, which was designed and constructed by Messrs. Hugh Smith and Co., Limited, can be distinguished on the right-hand side of Figs. 113 and 114, on Plate XXX, but it is more clearly shown in Fig. 116, on Plate XXXI. Drawings showing the general arrangement of the machine and its foundations, are reproduced in Figs. 120 to 123 above. The machine has a clear width of 41 ft. 6 in. between the housings, and is capable of working on high-tensile plates up to 41 ft. in length and up to 2 in. in thickness. The three rollers are of forged steel, the upper one being 21 in. in diameter and the two lower ones 16½ in. in diameter. Each of the rollers is supported by three sets of roller bearings, in addition to the journals at the ends, the bearings being mounted on brackets bolted on to heavy steel plate girders, as shown in Fig. 120. The upper roller and its supporting girder can be adjusted vertically, to alter the radius of curvature of the work, by means of screws operated by two 35-h.p. electric motors and worm gearing, and the lower rollers are fitted with sliding bushes so that they can be adjusted laterally to suit plates of different thicknesses. The lower rollers are both driven by a single electric motor of 260 h.p. by means of spur gearing arranged as shown in Figs. 120 and 121. All the gearing, with the exception of the two large wheels keyed on to the roller journals and the pinions which gear with them, is of cast steel with machine-cut teeth. The main driving motor, which runs at 585 r.p.m., is of the totally-enclosed, slip-ring type for three-phase current at 440 volts and 40 cycles. It is fitted with an electro-magnetic brake, and is operated by a horizontal oil-immersed, drum-type controller fitted with a hand wheel. The two smaller motors, for raising and lowering the upper roller, are of the same type, but run at 765 r.p.m., and they are operated by the vertical drum-type controllers mounted on a platform on the right-hand side of the machine, as shown in Fig. 116, on Plate XXXI. The three motors are of Messrs. Armstrong's own manufacture. The hydraulic crane

serving this machine, also shown in Fig. 116, was supplied by the engine works department of the firm at Elswick. It is capable of lifting a load of 8 tons, a height of 13 ft., at a maximum radius of 30 ft. and a minimum radius of 10 ft. The lifting motion is effected by a hydraulic cylinder and ram with 4 to 1 multiplying gear, and the slewing motion by a pair of cylinders with 2 to 1 multiplying gear. One of the two cylinders with 4 to 1 gear employed for racking the load along the jib, is clearly shown in Fig. 116.

(To be continued.)

COAL CONSERVATION IN THE UNITED KINGDOM.*

By Sir DUGALD CLERK, K.B.E., D.Sc., F.R.S., M.Inst.C.E.

ON April 21, 1904, I had the honour to deliver the twelfth "James Forrest" Lecture on "Internal-Combustion Motors." During the sixteen years which have elapsed those engines have made great progress, and their application to motor cars and transport has been enormous; they have also been applied to marine propulsion and the production of the aeroplane has been rendered practicable by the development of the light high-speed petrol engine. Ample material has accumulated for another "Forrest" Lecture on these engines, but notwithstanding the importance of the subject and my long connection with it, I consider it desirable to deal now with a still more vital matter—that of the conservation of fuel in the United Kingdom.

Our present industrial civilisation depends upon our supplies of fuel and motive power, and without coal, oil and motive power it would be impossible to support in comparative comfort our population of 46 millions. A return to the agricultural civilisation of 1750 would require the reduction of our numbers to one-third. This would be necessary if coal failed us or became unduly expensive.

The coal raised in 1913 was approximately 287·4 million tons; but of that, 189·1 million were retained and consumed here, the balance of 98·3 millions were exported, partly to supply bunker coal for our ships and partly to other nations to pay for commodities and services imported and rendered to us.

The total coal reserves at 2 per cent. per annum increase would be exhausted in about 250 years; but long before that time fuel would be so expensive that we would be hardly pressed to maintain the existing population—we would have arrived at a stage of stationary or receding numbers. It is accordingly of the utmost importance to study the engineering problems arising under the changed conditions.

The work of the engineer may be applied to extend the period of our present prosperity by reducing the total fuel consumption or by increasing the means of existence more rapidly, and so increasing the power of supporting a larger population for a shorter term.

The coal raised and retained in 1913 was consumed in the following manner.

TABLE I.—*Coal Consumption in the United Kingdom during the Year* 1913.

	Million Tons.
Railways	15·000
Coasting steamers (bunkers) ...	2·500
Factories	60·000
Mines	20·500
Iron and steel industries	31·000
Other metals and minerals	1·250
Brick works, potteries, glass and chemical works	5·750
Gas works	18·000
Domestic	35·000
	189·000

These numbers are taken from Table II, page 10, of the final report of the Coal Conservation Committee, and they have been calculated from the values given in the Coal Commission Report of 1903, by assuming a *pro rata* increase in the different items proportional to the total coal reserved for home consumption in the years 1903 and 1913.

It will be observed that the division does not give any direct indication of either the total coal consumption for motive power purposes or the total horse-power hours developed by the steam and other engines of the country.

Professor Bone gives his estimate of the division of consumption in that year as :—

	Per Cent. Approximately.
Power	40
Iron and steel works carbonisation...	27
Domestic	20
Transport	10

He agrees that it is difficult to state exactly the coal consumption in a given year for each of the above purposes, but he considers that the following values are tolerably accurate :—

	Million Tons.
Consumption in mines and factories chiefly for power	80
Iron, steel and other metallurgical industries	32
Bricks, ceramics, glass and chemicals	6
Railways and coasting steamers ...	17
Gas works	19
Domestic purposes	35

* The "James Forrest" Lecture, 1920, read before the Institution of Civil Engineers, April 20, 1920.

If these values be accepted, then power, gas works and domestic use consume between them 134,000,000 tons per annum, or about 71 per cent. of the whole coal consumption of the United Kingdom.

The Coal Conservation Committee* under the chairmanship of Lord Haldane arrived at the conclusion that 80,000,000 tons of coal were consumed in this country in 1917 for the production of power, including railways; they considered that only 25,000,000 tons would be required if the whole of the existing steam engines in separate factories, and the steam locomotives on railways were replaced by a great general system of electrical generation and distribution. For this purpose many of the existing electricity generating stations were to be purchased by the State, and large turbo-electric stations established at about 16 centres were to be erected and their mains so linked up as to cover the country with a network capable of supplying our whole power needs by electric motors. By this scheme the committee expected to save 55,000,000 tons of coal on power only, or to generate continuously 15,000,000 h.p. in addition to the 15,000,000 h.p. now required by factories and railways.

If this be true, the super-stations would certainly justify their existence. But is the scheme well founded?

Are the facts dealt with by the Coal Conservation Committee such as to justify the sweeping conclusions arrived at? Many competent electricians and most capable motive-power engineers have the gravest doubt as to the accuracy of the data presented and as to the outcome of the ambitious scheme advocated.

The report assumes an approximate knowledge of four values :—

(1) The amount of coal used in the United Kingdom for the production of power only.

(2) The amount of mechanical or electrical energy produced from this coal and used in driving workshops, mills, factories, electrical generation and railways by steam engines, reciprocating and turbine.

(3) Assumed (calculated from (1) and (2)) consumption of coal per brake horse-hour at present.

(4) Possible reduction of total consumption of coal by the proposed super-stations.

With regard to (1), an attempt is made to arrive at this value in Appendix A, page 23, of Final Report, by consideration of the values returned in the census of production for 1907. The conclusion is that in 1907 the estimated coal consumption in industry, including mining, was approximately 70,000,000 tons, but the whole of this coal is not used for power production because it includes "important amounts of coal used for purposes other than the generation of power, as in brick making, in chemical trades and in bake-houses."

It is assumed that only 75 per cent. of the total coal is used for power production in industry, that is 52·5 million tons. If railways be included the total consumption is stated to be at least 65,000,000 tons. It is further stated that the present (1917) consumption including railways is 80,000,000 tons. No reason is given for the increase between 1907 and 1917 from 65,000,000 tons to 80,000,000 tons, and no figures are quoted to show the probable increase from changing total consumption in the country during ten years.

In the list of purposes requiring the reduction by 25 per cent. above no allowance appears to be made for the large amounts of steam consumed in factories and mines for heating and general technical processes in industries like dyeing, bleaching, calico printing, tanning, hat manufacture, chemical trades, heating premises and others. Mr. D. Brownlie,† B.Sc., F.C.S., considers that these industries use more steam in this way than the same factories require for motive power. Mr. Brownlie states: "Also, in very many other industries, a considerable quantity of steam is used, even although the amount may be less than that used for power. It is not possible to find out what is the exact amount of coal used for the production of steam for purposes other than power, there being, for example, no statistics available showing the number of steam boilers at work in Great Britain."

Mr. Brownlie considers that the proportion of steam so included in power production is from 20 per cent. to 30 per cent. of the total. The 65,000,000 tons consumed in mining and industry is thus subject to a deduction of, say, 25 per cent., and the real value for power producing purposes, including railways, is more probably 48·7 million tons.

With regard to (2): The total output of mechanical energy produced from the coal used in driving workshops, mills, factories, electrical generators by steam engines, reciprocating and turbine (excepting railways) during the year of the census 1907, is estimated by the Coal Conservation Committee as 14,691,000,000 h.p.-hours. To estimate this value it is assumed that the nominal horse-power of steam engines may be used in connection with the rated capacity of dynamos, both as returned in the census, to determine by analogy the horse-power hours per nominal horse-power of the steam engine plant, as compared with the horse-power hours, per rated E.H.P., of electrical plant. It is considered probable that the ratio of average power developed to nominal horse-power and rated E.H.P. respectively is the same. This would be true if the steam and electric capacity rating were similar, but unfortunately the normal horse-power of a reciprocating steam engine is always lower than the actual horse-power capable of being developed. Many years ago it was by no means uncommon for the actual power of a steam engine to be four times the nominal. The practice as to nominal horse-power of a steam engine is to expect the actual power obtained to be at least one and a half times that of the nominal value. This would cause the power of the separate steam engines returned in the census to be higher than that used to determine the total horse-power hours of the plant per annum by Mr. Flux. For this reason I consider that the steam engine horse-power hours per annum are too low.

In my opinion the effect of this is to reduce the energy output to at least 70 per cent. of the probable total energy. On this view the total horse-power hours in 1907 was more probably

$$\frac{14{,}691}{0{\cdot}7} \text{ million} = 20{,}987 \text{ million horse-power hours.}$$

With regard to (3), my estimate of the total coal consumption under (1) during 1907 for steam motive power only, including railways, as explained is 48·7 million tons, deducting for railways 12·5 millions we get $48{\cdot}7 - 12{\cdot}5 = 36{\cdot}2$ millions, and that under (2) total energy output 20,987,000,000 h.p.-hours. The coal consumption per horse-power hour is therefore

$$\frac{36{\cdot}2 \times 2{,}240}{20{,}987} = 3{\cdot}9 \text{ lb. nearly.}$$

In the Committee Report the value arrived at, without correcting, for steam consumption other than motive power, and, without correcting, the nominal horse-power for steam engines is 8·03 lb. This number, however, is given up, and 5 lb. per horse-power hour is adopted from typical cases, as mentioned in (2), page 23: "To select for each of the large industrial areas of the country a number of representative examples of each important industry when full data are available." This is done by the committee, and they arrive at 5 lb. as stated, and point to the fact that Sir George Beilby had adopted that value also no less than seventeen years ago. I have also made a comparison on these lines.

At the time when the Coal Conservation Sub-Committee issued its interim report, April, 1917, no data existed giving the average consumption of coal for electrical generation. Fortunately, the establishment of the Coal Controller led to a thorough examination of the output and coal consumption of the electricity generating stations of the country, and on January 27, 1919, Mr. D. Wilson,* the technical adviser to the Coal Controller, gave the fuel and power data of the whole of the electricity supply undertakings of the United Kingdom utilising coal for the year ending March 31, 1918. From this it appears that there are 421 such undertakings which generated in the year, 4,674,000,000 Board of Trade units on an average consumption of 3·47 lb. of coal per Board of Trade electrical unit, or 2·59 lb. per electrical horse-power hour. We have thus accurate knowledge of the fuel consumption of at least 10 per cent. of the whole power of the country.

The textile trades are large power consumers, and their reciprocating steam engines are highly economical. We have no complete account of the whole motive power of the industry, but we have the results of careful tests made by competent and independent authority.

In the year 1915, the chief engineer of the Manchester Steam Users' Association reported on the fuel consumption of reciprocating steam engines such as are installed in textile mills. Thirty engines were tested, and it was found that compound engines working at about 100 lb. per square inch, consume about 2·7 lb. of coal per indicated horse-power net. Compound high-pressure engines consume about 1·85 lb. of coal per indicated horse-power net, and about 1·45 lb. when superheated steam is used. At 90 per cent. mechanical efficiency the brake consumption is :—

	Per Brake-Horse-Power Hour. Lb. Coal.
Compound 100 lb. per square inch...	3·00
Compound high pressure ...	2·05
Compound high pressure with superheat	1·61

If the nominal horse-power of the textile mills and factories in the country be supposed to be equally divided between the three types, then the mean consumption is 2·33 lb. of coal per brake horse-power hour. It appears probable, however, that the division is not equal, and a probable average for the textile industries is 2·5 lb. per brake horse-power hour. This is somewhat high for 1913, as first-class steam engine builders readily guarantee a steam consumption of 12 lb. per brake horse-power hour and this, with a Lancashire boiler with economiser and superheating, will only require 2 lb. per brake horse-power hour for coal. Allowing for some of the older engines, 2·5 lb. per brake horse-power seems a very probable figure for the textile industry.

In July, 1919, Mr. D. Brownlie, B.Sc., F.C.S., published a critical examination by him of the performances of 250 boiler plants, used for producing steam in different industries, including collieries, cotton mills, lace mills chemical manufactories, explosive factories, dyers and bleachers, woollen mills, hosiery mills and paper mills. He found that the maximum value for evaporation of water per pound of coal was 7·85 lb. as the average of 21 paper mills and the minimum value was 4·96 lb. as the average of 11 lace mills. Taking 20 lb. of steam consumption per brake horse-power hour as a common figure for an average factory steam engine, gives a fuel consumption of 2·55 lb. of coal per brake horse-power for the best and 4 lb. for the worst. The average value for the whole 250 boiler plant was 6·56 lb. of steam per pound of coal consumed. At 20 lb. steam per brake horse-power this would give a mean of 3·05 lb. of coal per brake horse-power.

A similar examination by Mr. Brownlie of 100 typical colliery steam boiler plants gives 5·44 lb. of water per pound of coal. If we assume that the colliery engines

* Cd. 9084.

† "Coal Saving by the Scientific Control of Steam Boiler Plants." By D. Brownlie, B.Sc., F.C.S., ENGINEERING, July 12 and 19, 1918.

* Discussion at the Junior Institution of Engineers.

require 30 lb. of steam per brake horse-power hour because of the nature of their work, then the average coal consumption for the collieries per brake horse-power hour is 5·5 lb. of coal. Pumping engines for mines, however, are highly economical and consume about 2 lb. of coal per pump horse-power hour.

Rolling-mill engines used in iron, steel and other metal industries were somewhat extravagant in fuel consumption; in former days 10 lb. of coal per brake horse-power hour was common. Recent improvements for exhaust steam recovery and the introduction of steam-driven electrical drive has greatly improved on this consumption, so that 3 lb. of coal per brake horse-power hour is not uncommon. It only remains to discuss the case of small high-pressure non-condensing engines driving small factories and separate machines. In these engines 5 lb. of coal per brake horse-power hour is required.

To arrive at an approximate average for the whole country by consideration of separate typical tests it is further necessary to study the distribution of the total steam power of the country among the different engines of greater and less economy. The data at our disposal is somewhat vague as it depends on the returns made at the census production of 1907. At page 24, Table II, of the Coal Conservation Committee Report it is estimated that the total coal consuming horse-power of the United Kingdom is 9·354 million.

The four large divisions are :—

	Million Horse-Power.
Mining and quarries	2·427
Iron, steel, shipbuilding, engineering...	1·926
Textile trades	1·900
Public utility service	1·722
	7·975

The four divisions account for 7·975 million horse-power out of 9·354 million, or 85·4 per cent. of the whole. The division in percentage is :—

	Per Cent.
Mining and quarries	26·0
Iron, steel, shipbuilding, engineering...	20·6
Textile trades	20·3
Public utility service	18·5
Other purposes	14·6
	100·0

It is now possible to estimate the average coal consumption for steam power in the whole country as follows :—

Mining and quarries ...	26·0 × 5·5 =	143·0
Iron, steel	20·6 × 4·0 =	82·4
Textile trades ...	20·3 × 2·5 =	58·0
Public utility ...	18·5 × 2·6 =	48·2
Other purposes ...	14·6 × 5·0 =	73·0
	100·0	404·6, say 405

Then the average for the United Kingdom is—

$$\frac{405}{100} = 4{\cdot}05 \text{ lb. of coal per brake horse-power hour.}$$

I have thus arrived at two values. The first is 3·9 lb. of coal per brake horse-power, estimated on census of production data corrected by allowing for steam production other than for motive power and for error in total horse-power hours as determined by the Coal Conservation Committee due to allowance necessary for ratio between developed and nominal power. The second value is 4·05 lb. of coal per brake horse-power hour, and this is estimated by considering the average of many typical steam engines. The agreement is close.

With regard to (4) which considers the possible reduction of total coal consumption by the proposed superstations, it has been shown in the discussion on (1) that after allowing for steam used for purposes other than motive power the Coal Conservation Committee estimate of 65,000,000 tons consumption is reduced to 48·7 million tons. If we assume with the Coal Conservation Committee that super-stations in the early future will generate 1 E.H.P. hour on 1·56 lb. of coal, then the possible consumption by the complete substitution of such stations for existing stations and power-producing steam engines, assuming the figure of 4·05 lb., is :

$$\frac{1{\cdot}56 \times 48{\cdot}7}{4{\cdot}05} = 18{\cdot}77 \text{ million tons.}$$

The saving is 29·9 million tons. The saving, as contemplated by the committee, on 65,000,000 tons, the consumption for stationary engines, excluding 15,000,000 tons allowed for railways, is :

$$65 - \frac{1{\cdot}56 = 65}{5} = 44{\cdot}7 \text{ million tons.}$$

I have not yet considered the question of coal consumption of locomotives for which the committee allow a present consumption of 15,000,000 tons per annum. Mr. R. T. Smith, in his presidential address to the Institution of Electrical Engineers states that if all the railways of the country be electrified then it is possible to save from 7,000,000 tons to 8,000,000 tons of coal per annum. Other electrical engineers are not so hopeful, but to complete our comparison we shall take from Mr. Smith a saving of 7·5 million tons per annum on railways; we then get as total "saving" 29·9 + 7·5 = 37·4 million tons per annum. Taking all the facts into consideration and assuming electricity in the future to be used for the generation of power and light only, then a reduction to 1·56 lb. of coal per brake horse-power hour would give a possible saving of not more than 37,500,000 tons of coal per annum. The saving of 55,000,000 tons expected by the committee is, in my opinion, based on fallacious reasoning.

Effect of Using Electricity for Generating Heat on Possible Coal Economy.

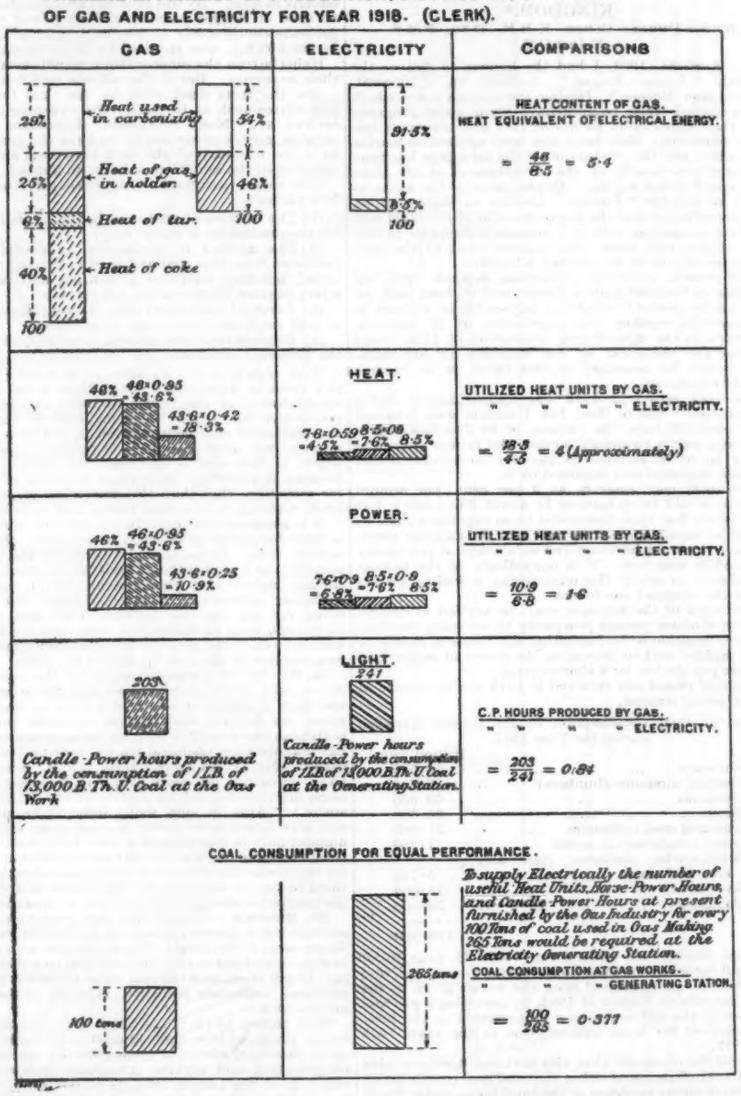
As has been stated, the foregoing discussion assumes that power and light are to be generated, not heat; but the Committee Report clearly intends to generate heat also and expects to do so with economy superior to the existing systems of coal and gas combustion. In Lord Haldane's prefatory note to the Interim Report of the Power Generation and Transmission Sub-Committee it is stated that : "The question of the conservation of coal so far as it falls within the reference . . . is the question of economy in the use of coal through supplying electricity for power and other forms of energy."

And at I (13), page 9 of the report, I find : ". . . and, being within reach of the community as a whole, the great benefits of an increase in the use of electricity for domestic purposes . . ." On the same page 9, in a footnote to I (9), it is stated with regard to the committee's expected saving of 55,000,000 tons per annum : "This figure takes no account of the saving possible on domestic coal consumption as the result of a comprehensive system of electric power distribution." The footnote on page 14 also states : "In addition there are the various domestic uses of electricity, such as heating, cooking and power, which are capable of rapid development." And at the end of 21, page 15, it is said : "The economy of a combination of all requirements, power, traction, lighting and heating, is fundamental." At 32, page 19, the coal affected by the proposed power changes is stated as at least 80,000,000 tons, and a footnote expands this quantity as follows : "The coal consumption which would be affected indirectly is much larger. The coal consumption for domestic purposes, *including most of the coal used in gas works*, would be affected by an improvement in the efficiency of production of electricity, for, as the price of electricity fell, *so would its use for lighting, heating and cooking*, already very considerable, *increase in substitution for the direct use of coal and gas for these purposes*." (The italics are mine.)

From these statements it is evident that the committee intend the general economy of the improved efficiencies of the super-stations to include the supply of heat also, and they expect coal conservation to be further improved by this addition. The expectation of economy is evidently effected by heat supply as well as motive power and light. To test this matter it is desirable to consider first the question of heat supply by electricity and by coal gas.

TABLE II.

THERMAL EFFICIENCY OF PRODUCTION, DISTRIBUTION, AND USE OF GAS AND ELECTRICITY FOR YEAR 1918. (CLERK).



Gas Compared with Electricity for Domestic Heating.

I have already discussed for coal gas, the thermal efficiency of production and distribution of coal gas from the heat of the coal used in the process of carbonisation to delivery into the gas-holder and the distribution to the consumer. By comparing the results obtained by the large London companies and many provincial companies, and comparing these results with the total coal carbonised in the United Kingdom and the total gas produced all for a complete year's working, I have arrived at the conclusion that the average efficiency of gas production for the kingdom is 46 per cent. and the efficiency of distribution is 95 per cent., so that the consumer receives at his premises 43·6 per cent. of the heat used at the gas works ready to produce that quantity of heat on combustion. I have also similarly estimated the thermal efficiency of the gas in use for domestic and manufacturing purposes. The main uses are gas fires, boiling and heating water, gas cooking by oven and metal heating and melting. The efficiency of the gas in

use is 42 per cent., that is, the final efficiency referred to the heat consumption at the gas works is $43 \cdot 6 \frac{1}{2}$ by $0 \cdot 42 = 18 \cdot 3$ per cent.

Table II, on the opposite page, shows the present efficiencies of production, transmission and use for gas and electricity in the year 1918. Electricity generated at a fuel consumption of 1·56 lb. of coal per E.H.P. hour gives a thermal efficiency of production of 13 per cent. That is, of 100 heat units consumed in the boiler furnace the equivalent of 13 are generated within the central station. The efficiency of transmission for short distances is 90 per cent., and the electricity consumer receives on his premises $13 \times 0 \cdot 9 = 11 \cdot 7$, per cent. of the heat consumed in the thermodynamic transformation at the superstation. The efficiency of electricity in use for domestic and industrial purposes such as electric heating of rooms, electric heating and boiling water and industrial metal heating and melting is estimated by me as 59 per cent. The consumer thus uses in his apparatus $11 \cdot 7 \times 0 \cdot 59 = 6 \cdot 9$ per cent. of the heat units consumed at the generating station.

For equal heat actually applied to the work, gas thus returns 18·3 per cent. of the heat of production, distribution and use, while electricity only returns 6·9 per cent. For equal heat work electricity thus consumes $\frac{18 \cdot 3}{6 \cdot 9} = 2 \cdot 65$ times the coal of the country to do the same work. How would this fact affect the conclusions of the Committee Report? Assume for the purpose of testing the matter that the super-stations are in being—generating and distributing by electricity the whole of the power estimated as in present use—then the total coal consumption per annum will be 18·8 million tons at 1·56 lb. of coal per E.H.P.-hour. The whole consumption under the present system of industrial and not collective power generation would be, as I have shown, 48·7 million tons, the saving shown is thus 29·9 million tons. This assumes all private power installations and nearly all existing generating stations to be abolished and replaced by the new super-stations. Assume now that gas works in existence use 18·8 million tons of coal to generate heat at 46 per cent. efficiency of production and 18·3 per cent. efficiency of production, distribution and use. The total fuel consumption between power by electricity and heat by coal gas will be $18 \cdot 8 \times 2 = 37 \cdot 6$ million tons. Assume the gas works to be abolished and electric generating stations to be expanded so as to supply current for heat supply at the same generating efficiency as for power, and the heat to be the same as total quantity as produced and used by way of the gas works; the 18·8 million tons of coal will then be increased 2·65 times, that is, $18 \cdot 8 \times 2 \cdot 65 = 49 \cdot 8$ million tons of coal per annum will be consumed for the heating load. The total coal consumed for the combined supply of power and heat by way of electrical generation is thus $18 \cdot 8 + 49 \cdot 8 = 68 \cdot 6$ million tons, and the total coal consumed for the separate supply of power by electricity and of heat by gas works is $18 \cdot 8 + 18 \cdot 8 = 37 \cdot 6$ million tons, and the loss by adopting electricity for heating is 31,000,000 tons per annum.

It remains to compare the result with the present fuel consumptions due to the existing systems. The consumption for stationary power I have estimated as 48·7 million tons per annum, and adding the assumed consumption of gas works for heat $48 \cdot 7 + 18 \cdot 8 = 67 \cdot 5$ million tons. If, then, the ideas of the committee be carried out as to the supply of electricity for heating, cooking and industrial metal melting and treating, as well as for power, the whole assumed saving on power will be lost and 68·6 millions of coal per annum will be consumed instead of 67·5.

In my opinion, on the facts which I have shown, the super-stations will not justify their existence. The Government scheme is wrong, and the sweeping conclusions arrived at by the Coal Conservation Committee are unjustifiable. In other words there is no possibility of saving 55,000,000 tons per annum of the fuel of the country by carrying out the full scheme. Small fuel savings are possible by limiting the use of electricity to light and power, but such savings are being rapidly and safely effected by the individualistic system of separate power units under which Great Britain has led the way for more than 100 years.

In so far as electricity displaces gas for heating purposes in so far would the coal consumption of the country be increased. The committee also look to considerable displacement of coal used for domestic purposes by electric heating; the average heating efficiencies of coal as used for domestic consumption are not so high as gas, but they are higher than electric heating efficiencies, so that no saving could be effected here by the application of the committee's views. No heat can be saved by electricity here. Are there then other methods by which the country's fuel can be saved, or increased work obtained from the same quantity of fuel? I shall now discuss this question.

(To be continued.)

AIR MINISTRY COMPETITIONS FOR AEROPLANES AND SEAPLANES.

THE final regulations for the Air Ministry aircraft competitions, the objects of which are to ascertain the best types of aircraft which will be safe, economical and comfortable for air travel, have now been approved and can be obtained from the Secretary, C.G.C.A. (C.A.L.), Air Ministry, Kingsway, London, W.C. 1. Three prizes are offered in each of the three following classes: Small-type aeroplanes with seating accommodation up to six persons, large-type aeroplanes with seating accommodation for seven or more persons, and amphibious seaplanes with seating accommodation for not less than two persons; the accommodation is in all cases exclusive of the crew. The prizes for the large-type aeroplanes are 20,000*l.*, 8,000*l.* and 4,000*l.*, while those for small-type aeroplanes and seaplanes are 10,000*l.*, 4,000*l.* and 2,000*l.* The competitions are open to British subjects for machines and engines designed and manufactured in the British Empire, and although secondary equipment of foreign manufacture may be employed, competitors using it will be penalised by the deduction of marks. The full load for both types of aeroplanes is to include, in addition to the passengers, petrol and oil for a flight of 450 miles at 3,000 ft., and at a speed of not less than 80 m.p.h., and, in the case of seaplanes, petrol and oil sufficient for a flight of 350 nautical miles at 1,000 ft., and at a speed of not less than 70 knots, must be included in the full load. The machines will be required to carry out landing and getting-off tests, reliability and economy tests, and marks will be allocated according to the results of these tests, as well as for speed and general features of design. Seaplanes will also be subjected to mooring-out tests, touring and taxi-ing tests and marks will be allocated for seaworthiness in addition to the properties above mentioned, which apply to both aeroplanes and seaplanes. Full particulars of the conditions and tests for both large and small types of aeroplanes are given in Form A, while similar information with regard to seaplanes is given in Form B. Forms C, D and E set forth the rules and regulations governing the competition and include a form of entry; any or all of these forms can be obtained on application to the secretary at the above address. The competitions for aeroplanes will commence on August 3 next, and for seaplanes on September 1. Entries for the former must be made before June 1, and for the latter before July 1. It may be interesting to note, in conclusion, that the draft rules previously issued have been revised in consultation with the Society of British Aircraft Constructors, and changes made in the system of marking which, while retaining the most important attribute of safety, will have the effect of ensuring all-round excellence in the successful machines. The results of the competition will be awaited with interest, and they should have an important effect on the development of civil aviation in this country.

"THE DEVELOPMENT OF METAL CONSTRUCTION IN AIRCRAFT."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the communications of Mr. A. J. Sutton Pippard, on page 421 of ENGINEERING, March 26, and Mr. A. H. Naylor, on page 490 of ENGINEERING, April 9, each of whom directs attention to the manner in which the various experimental results from the Avro spar specimens have been compared.

It was recognised that the Perry formula in equation (2a), page 375, gave only a first approximation to the total bending moment, and an indication is given on page 376 of the error involved in the use of this equation. It underestimated the stre s developed just as the test specimens stiffened with loading boxes developed less stress than they otherwise would for a given loading; the approximation was on the right side. The formula was adopted in this particular case because of its simplicity and because the experimental results which were to be compared were taken from tests on a large number of widely differing types of steel spar specimens which were mostly built up by hand in short test lengths, and of steel strip which was not formed by the most suitable process. The specimens were thus liable to premature secondary failure, and in certain cases faulty workmanship caused the early failure.

Test results from further spar specimens carefully built up in jigs, in dead straight lengths and from specially drawn or rolled steel strip, and with suitable loading boxes for the end thrust and for the transverse loading, should certainly be compared with results calculated from more accurate formulæ, such as are given by Mr. Pippard and Mr. Naylor, and I am convinced that with the better designs the test and the calculated results will agree very closely at least up to that loading at which failure (generally secondary) commences; thereafter, at higher loading, the deflection of the specimen will increase more rapidly, and the secondary failure may reduce the effective moment of inertia of the section, rendering very difficult the calculation of the induced stress.

The curve S_0 given by Mr. Pippard, on page 421, lies so far above the curve S that probably the experimental results from a well-designed, stable, specimen will fall below S_0.

With regard to Mr. Naylor's remark that there is still a wide difference between the theoretical and experimental curves S and L, I would repeat that L is the locus of the *failing* stresses of a set of widely differing designs, all of which could have been appreciably improved in one or more respects. A reference to curves T_1 and T_2, in Fig. 25, page 376, will illustrate the improvement effected in one of the best designs by heat treatment only. A corresponding improvement is possible in many of the other designs. Curve L will therefore approach closer to the ideal curve S as the designs improve and the divergence from S of the final portion of an experimental curve such as T_2 depends largely on the manner of failure as indicated above.

The divergence of L from S is therefore by no means entirely due to the manner in which these curves are derived. The assumption made when replotting the experimental failing stresses in Fig. 25, reducing the weights of all test specimens to a standard 0·53 lb.-ft. run is, under the circumstances, of a preliminary series of designs such as the above Avro test specimens, quite justifiable. After the failing stresses had been replotted in Fig. 25 a certain amount of judgment was exercised before the locus L was plotted.

I fear that only in a limited number of cases will secondary failure be avoided in these laterally-loaded struts if a light structure is essential, and if suitably heat-treated material with a high elastic limit is employed. The locus L is possibly only of secondary importance, the main consideration being the development of each promising type of design and the determination of the stress at which failure, whether secondary or primary, first shows. Up to such stress the experimental stress load curve should agree with the corresponding calculated ideal curve.

With regard to Professor F. C. Lea's communication on page 458, April 2, I certainly had no intention to withhold credit from whom credit is due, and reference is made at the end of my paper to most of those concerned. I may, however, here add the names of Professor Lea's two assistants, Mr. E. Coupland and Mr. A. H. Naylor, also three members of my own staff at the Research Department, Air Ministry, Mr. J. Robertson, Mr. C. C. Copperthwaite and Mr. B. A. Duncan, to whom I am greatly indebted.

The whole research on metal construction was initiated and financed by what is now the Research Department, Air Ministry, and I understand that the expenses of the testing at Birmingham University under Professor Lea were covered by a grant from the Department of Scientific and Industrial Research, which reported to the Air Ministry on the work done.

The major portion of the shorter spar specimens were tested at Birmingham University, and test reports were submitted by Professor Lea to the Air Ministry. A smaller portion of the shorter spar specimens were tested at Messrs. Brunton's Laboratory, Musselburgh, by Professor Goodman, and others were tested by individual aircraft firms. The complete spars and the complete planes, &c., were tested mainly at the R.A.E., Farnborough.

The actual designing was done by the various aircraft firms and largely by the gentlemen mentioned in my paper, by all those mentioned above, by myself and, lastly, but by no means least, my predecessor, Dr. A. P. Thurston.

All information on these matters was collected by the "Metal Construction" Section of the Research Department of which I was director, and that information was grouped, correlated, &c., by us last summer, but to describe me or any member of my staff as liaison officer between Professor Lea's laboratory and the Air Ministry is rather a stretch of imagination.

I am, Sir, yours faithfully,

JOHN S. NICHOLSON.

James Watt Engineering Laboratories, The University, Glasgow, April 14, 1920.

"THE CONSTITUTION OF COAL."

TO THE EDITOR OF ENGINEERING.

SIR,—I esteem greatly the interest and appreciation shown to our researches on coal, to which you so kindly gave prominence in ENGINEERING of April 9, page 485. As a point of historical justice to my collaborators may I add to the information you publish the fact that Dr. Wheeler and I have for some years been working on a rich variety of *apparently* unrelated themes, but that they are all parts of a carefully thought-out attack on the whole problem of the constitution of coal on which we embarked before writing our first joint memoir ("The Constitution of Coal," published by the Government in 1918). With one exception (that of Dr. Sinkinson) all the papers you mention in your article arose as a result of this ramifying research. The work published since 1918 by Dr. Wheeler and his assistants and collaborators, also that of Dr. Lessing and other work about to appear, is the direct continuation of the plan of the joint researches initiated by Dr. Wheeler and myself some years ago.

Yours faithfully,

MARIE CARMICHAEL STOPES.

Palæobotanical Laboratory, Leatherhead, Surrey, April 16, 1920.

THE LATE MR. JAMES METCALFE.—We regret to have to record the death, which occurred on the 12th inst., at Oswestry, of Mr. James Metcalfe, of Sheen Bank, Marple, a partner in the firm of Davies and Metcalfe, Limited, Romiley. Mr. Metcalfe was born on September 25, 1847. He served his apprenticeship with Messrs. Sharp, Stewart and Co., locomotive builders, from 1862 to 1867. He afterwards became locomotive superintendent to the Manchester and Milford Railway, which position he held from 1867 to 1880. He was then managing director of the Patent Exhaust Steam Injector Company. Messrs. Davies and Metcalfe's injectors are extensively used on locomotives. Mr. Metcalfe was elected a member of the Institution of Mechanical Engineers in 1906.

PRODUCTION OF PIG-IRON AND STEEL IN MARCH, 1920.—The production of pig-iron in the United Kingdom in March, 1920, amounted to 699,000 tons, which is the highest figure attained in any month since the armistice. The average daily rate of production was about 22,500 tons, compared with 22,200 tons in February, and 21,500 tons in January. The production of steel ingots and castings was also the highest since the armistice, being 840,000 tons, as compared with 798,000 tons in February and 754,000 tons in January. The production of steel in the first quarter has therefore been at the rate of nearly 10,000,000 ingot tons per annum. The 699,000 tons of pig-iron included 254,000 tons of hæmatite, 247,000 tons of basic, 181,000 tons of forge, foundry and other qualities, and 17,000 tons of alloys. The production of pig-iron in the United States in March amounted to 3,376,000 tons.

THE TWIN-SCREW MOTOR SHIP "AFRIKA."

CONSTRUCTED BY MESSRS. BURMEISTER AND WAIN, LIMITED, ENGINEERS, COPENHAGEN.

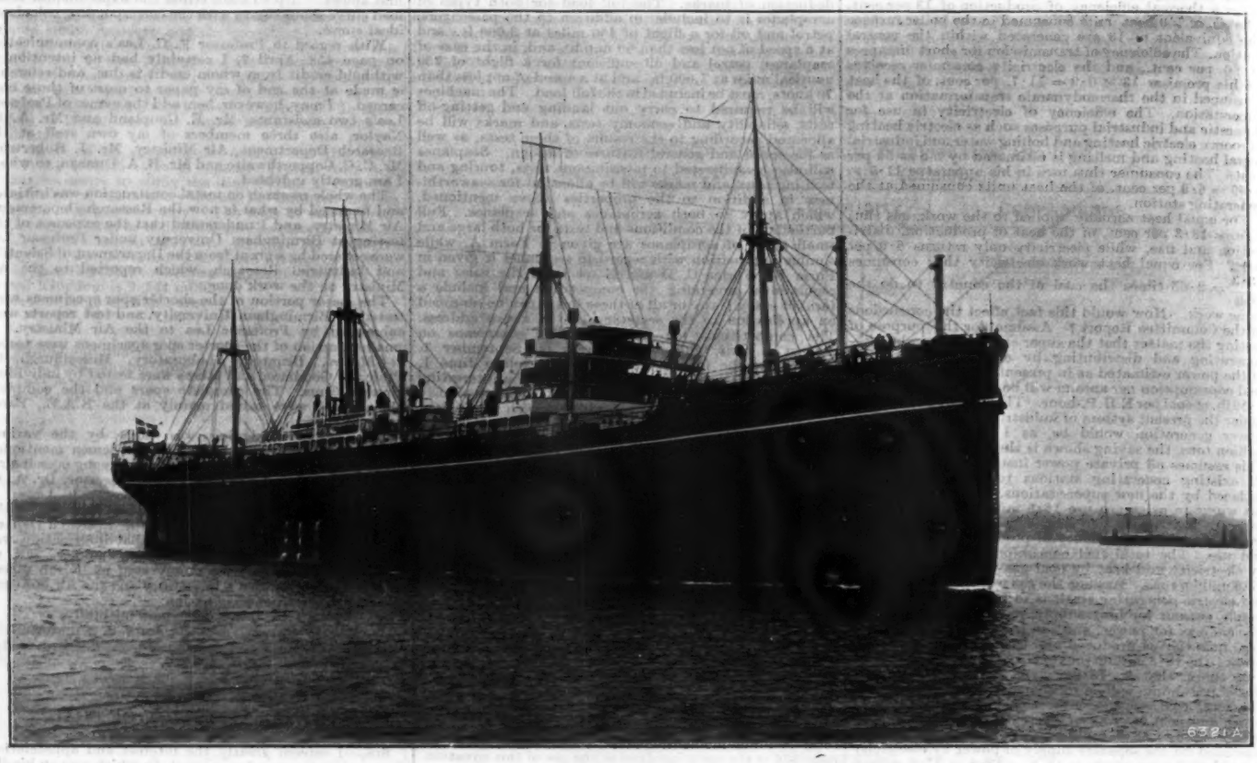


FIG. 1.

THE motor ship Afrika, of which we give an illustration in Fig. 1, above, built by Messrs. Burmeister and Wain, of Copenhagen, Denmark, to the order of the East Asiatic Company, of the same city, represents the latest and largest of ocean-going motor ships. The vessel is designed for the trade between Europe and the Far East and other distant places, her oil fuel capacity being sufficient for a journey of one and a-half times round the world.

The vessel is built to class 100 A1, British Lloyd's Special Survey, awning deck with freeboard, and with certificate for carrying fuel oil in double bottom. The scantlings of the more important parts are in excess of Lloyd's requirements, and the outfit and machinery are in every way of the latest design.

The vessel has a length of 464 ft. 6 in. overall, or, between perpendiculars, of 445 ft. Her moulded breadth is 60 ft., and depth moulded to lower deck 24 ft., to upper deck 33 ft. 3 in., and to awning deck 42 ft. Her gross tonnage is 8,597 registered tons, and net tonnage 5,468 tons. Her deadweight is 13,300 tons. The capacity of her hold is about 700,000 cubic feet of grain. The vessel has an oil fuel capacity of about 1,500 tons, and her engines develop 4,500 indicated horse-power.

The hull is divided by seven watertight bulkheads and three continuous decks, and in the refrigerated holds with a platform deck. The width of the cargo hatch is 18 ft., and the main hatch has a length of 37 ft. 4 in. The deck machinery is electrical throughout and consists of 20 winches of 5 tons, 3 tons, and 1½ tons lifting power, and the corresponding derricks of 5 tons, 3 tons and 2 tons capacity. The foremast is equipped with a 30-ton and the main and mizzen masts each with a 15-ton derrick. The electric windlass for the 2·433 in. cable was constructed by Messrs. Burmeister and Wain, as was also the hydro-electric steering engine, which is perfectly balanced with plungers fore and aft of the rudderstock. The deck officers and passengers have their accommodation in the foremost deckhouse and in the houses on top of the same, which are specially fitted out to meet the requirements of the tropics. The culinary arrangements are in accordance with the latest practice, refrigerated provision rooms, ice generator, &c., being provided.

The engine staff and the crew are berthed amidship and in the poop. For the crew the rooms are fitted out for two men each, and five separate messrooms are fitted for the officers and men of different grades.

The equipment is complete with all up-to-date refinements for minimising manual labour, saving time and adding to the safety of the ship—as, for instance, with electric sounding machine, "Navigator" log recorder, loud-speaking telephones, Clay's order transmitter, powerful wireless installations, &c.

The machinery consists of one set of Burmeister and Wain's four-cycle twin-screw standard marine Diesel engines of the enclosed, forced-lubricated, crosshead type, detailed drawings of which have already been reproduced in ENGINEERING.* Each engine has six cylinders, with a cylinder diameter of 740 mm. and 1,150 mm. stroke, both engines being able at normal load at sea to develop a total 4,500 horse-power at 115 revolutions a minute. A view of one set of engines is given in Fig. 2, on page 550. Each engine is fitted with a main compressor for injecting air, enclosed, forced-lubricated, and of the three-stage type. According to the firm's usual practice, all the other necessary pumps and the auxiliary machines are electrically driven, independent of the main engines. For the production of the necessary current for working the auxiliary machinery, as well as the steering gear, windlasses, and winches, the ship is fitted with three auxiliary Diesel engines, of which one is shown in Fig. 3, on page 550, each of 100 horse-power, and, further, an engine of the same size is provided for the refrigerating machinery. Each of the other engines can serve as a stand-by.

The trial trip was run on March 27, and went off very satisfactorily. All the engines were tested and were put through a series of manœuvres. During the trials several runs were carried out over the measured mile at an average speed of 13¼ knots. The engines form the second set built for this ship, as the first set was delivered to the United States Shipping Board in 1919. When the machinery of the Afrika was half completed, the United States Shipping Board wished to acquire a set of such engines as soon as possible, in order to obtain experience with them, and the East Asiatic Company consented to the transfer being made.

* See page 12 *ante*.

PATENT LITIGATION IN 1919.

DURING last year several patent actions were decided which are of interest to engineers, and we summarise the results in the more important of these.

Amendment of Specification.—The specification of a patent relating to a high-speed tool steel claimed the addition of cobalt up to 15 per cent. to the known compositions. It was desired to amend the specification to limit the claim to the use of about 4 per cent., but this amendment was refused.

In another case a patent relating to the treatment of metallic tungsten having been held by the House of Lords to be invalid it was sought to introduce a disclaimer. The original main claim was for working tungsten by subjecting the metal in a coherent form to the action of heat whilst it was being operated on or manipulated. It was desired to add a statement in the specification that by the expression "coherent form" the patentees excluded any forms of tungsten other than those agglomerated from tungsten powder and rendered very dense and strong by a heat treatment very near the melting point. The Court would not allow the amendment because they held that it would import into the specification for the first time the element of selection and would make the invention claimed substantially different from that originally claimed.

Petitions for Extension.—Several petitions for extension of the patent term were heard with varying results. In Fleming's patent for the "Fleming" valve it was held that the remuneration of the petitioners had not been inadequate and no extension was granted. It was admitted that they had made a profit of about 8,500*l.* on the sale of the valves and it was proved that they had received a sum of over 18,000*l.* on the shares received on the sale of foreign patent rights to subsidiary companies and that they had claims pending against the British Government.

In connection with Michell's patent for thrust bearings, it was held that the invention was very meritorious and the remuneration of the inventor inadequate. The remuneration of the inventor had been about 15,000*l.* An extension of seven years was, therefore, granted. This patent has been fully described in ENGINEERING.

The Fleming and Gale patent for trawl net otter

boards was held to be of great practical utility and was extended for three years.

Muir's patent for shock absorbers, comprising a ball chamber surrounding the central hub of a wheel and containing a number of balls superimposed in layers and having a free space so that they can receive and distribute the shocks by slipping over one another, was held to be of great utility and so different from anything that had been suggested before that an extension would not interfere with any vested interest. The patent was extended for seven years.

Grant of Patents.—Several important decisions were given by the chief examiner and by the law officer on the principles governing the insertion of specific references in specifications during their procedure through the Patent Office.

In one case, although a prior patent was admitted to be a pioneer patent, as it had expired the chief examiner refused to direct a specific reference to be made in a later case to it, and this refusal was upheld by the law officer.

Misleading Specification.—In a patent for drying and preserving milk and milk-like products, it was held that the patent was invalid by reason of a material representation as to the utility and result of the invention contained in the specification being inaccurate because it was found that the fat and case in the milk were not as alleged obtained in a dry but otherwise unalterable form. This view was taken by the House of Lords affirming both the action of the Court of Appeal and of the action of the judge in the first instance.

Public User.—In a case where steel of a composition claimed in the specification of a patent for a high-speed tool steel had been sold prior to the date of the patent and any purchaser could by analysis have known what the composition was, the patent was held to be invalid and it was held unnecessary to show that the composition had, in fact, been so ascertained or that there was a probability that an analysis had been made. This is the patent for a high-speed tool steel produced by the addition of up to 15 per cent. of cobalt, the example in the specification of a high-speed tool steel of exceptional quality being an alloy of steel with about 0·70 per cent. carbon, 5 per cent. chromium, 18 per cent. tungsten, 1 per cent. vanadium, 0·75 per cent. molybdenum and about 4 per cent. cobalt.

Subject Matter.—Two important cases involving the subject matter of patents have been reported, one on an action by the British United Shoe Machinery Company, Limited, and the other against the London General Omnibus Company, Limited.

In the first case the patent was for a process for permanently securing in lasted condition the upper of a stitched-down boot or shoe that comprises as a characteristic conforming the upper to the shape of the last by successively presenting various points selected by the operator to a machine having a tool . . . which forces the material of the upper into the angle between the side of the last and the projecting sole margin or between the equivalent parts of the shoe, and securing each portion of the upper to the sole in lasted position whilst it is held in the said angle by the tool by inserting an individual permanent fastener, such as a staple in the angle through the upper and into the sole at the selected points. At the trial it was proved that the effect and desirability of getting the fastening into the angle of the crease were well known and that practicable permanent fasteners in the form of light wire staples had been used, so it was held that the idea comprised in the patent was not entitled to exceptional protection on one consideration, not to be practical by any means specified and the patent held to be invalid.

In the second action referred to, the patent was for a safety device or lifeguard for motor vehicles, and it was upheld although side guards and front guards for tramcars were well known an unsatisfied demand for an efficient guard in the case of motor omnibuses being proved to have existed, and the problem to be solved in the case of such vehicles being different from that which had been solved in the case of tramcars. The patent was for a guard for motor vehicles consisting of a frame carried along a side of the vehicle and crossing the path of the rear wheels at a slight inclination.

Sufficiency of Specification.—The Privy Council considered on appeal from Australia certain patents relating to obtaining precious metals from their ores. They held that where an invention was for an improvement on an old solvent for the extraction of such previous metals and the specification contained no indication of any particular way of working the invention, and a certain change in the use of the old method was not pointed out, that the class of persons to whom the specification was addressed would so use the new solvent as to destroy its efficiency and the patent was, therefore, invalid because of the insufficiency of the specification. The patented process consisted in mixing a solution of a bromide, a bromate, a cyanide and an acid with or without the addition of an oxidising agent for the formation of cyanogen bromide.

Trade Marks.—In connection with trade marks, registration on a special application of the surname Burford was permitted for commercial motor vehicles and Winget for certain machinery. The surname Avery was also allowed to be proceeded with in connection with weighing machines, but an application for the registration of a mark consisting of four figures in a row the inner figures being circles, and each outer one a device somewhat of the shape of a pear was refused, because these were one form of perforation covered by letters patent for loose-leaf binder systems, and it was held that as the result of the registration the public would not be able to utilise the invention to the full extent on the expiration of the patent.

INDUSTRIAL NOTES.

In our two last issues we stated the offer made by Government for an increase in the miners' wages and gave the result of the miners' ballot on the said offer, the figures being for accepting the offer 442,704, and against 377,569, a majority for acceptance of 65,135. The following is the official report of the conference of delegates which met on the 15th inst. to hear the result of the ballot:—

"The result of the ballot was reported and was accepted by the conference. The chairman said a meeting with the Coal Controller would be held for the purpose of making arrangements for the payment of the advance, such payment to be made on April 30 or May 1, whichever happened to be the pay day. The advance will be retrospective from March 12. The question of the advance to workmen who are members of the Federation, but work at concerns not under the Coal Controller, was remitted to the Executive Committee, with the clear understanding that the advance must be paid in their case from the same date (March 12) as in the case of those men within the province of the Coal Controller. It was also decided that a letter be sent to those concerns outside of the Coal Control Department informing them of that decision. The Secretary (Mr. Frank Hodges) intimated to the conference that a joint meeting of the representatives of the miners and the mine-owners, with the Coal Controller, would be held on the 29th inst., for the purpose of further considering the question of continuous week-end working and overtime."

Mr. W. Straker (chairman of the Business Committee) made the official statement, and added that the decision to accept the result of the ballot as a settlement was unanimous and binding. Mr. W. Brace, M.P., on being questioned as to the attitude of South Wales, replied that "South Wales was as safe as houses."

The effect of the increase contained in the accepted offer will be an additional cost of between 30,000,000*l.* and 35,000,000*l.* per annum. Mr. Frank Hodges estimates that 80 per cent. of the men will come under the flat rate minimum, and the rest will benefit by the percentage offer.

The following are the results of several district votes:—South Wales, for acceptance, 47,496; against, 116,621; Lancashire, for, 17,509; against, 62,466. Scotland, for, 54,708; against, 51,564. Yorkshire, for 91,555; against, 29,388. Durham, for, 72,600; against, 39,438.

In connection with this question of the advance in miners wages, it is interesting to put on record a statement prepared by the British Commonwealth Union, whose offices are at 24, Abingdon-street, S.W. 1. This Union state that in the report on the coal industry prepared by Messrs. Alfred Tongue & Co., at the request of the Prime Minister, the output for the year ending March 27, 1920 (the last Saturday in March) was estimated at 230,000,000 tons. In Messrs. Tongue's report the output figures actually dealt with covered the 31 weeks up to November 1, 1919, at which date the production for the period was 132,109,000 tons. During the following 21 weeks the output was 98,560,000 tons, so that the output for the 52 weeks down to March 27, 1920, was 230,669,000 tons, or 669,000 tons in excess of Messrs. Tongue's estimate. Their estimate was based on the employment of 1,154,000 hands, whereas some time before March 27 the number had reached 1,184,000. The increased number of hands at work should have resulted in a total output of about 232,000,000 tons, so that Messrs. Tongue slightly over-estimated the output per man. During the 13 weeks ended March 27, 1920, the output was 61,596,000 tons; this period did not contain any holiday time except New Year's day, and therefore the equivalent annual output cannot be put higher than 240,000,000 tons. The average number at work appears to have been 1,182,000, and if the output per man had been as high as in 1913, the equivalent annual output should have been 306,000,000 tons; thus, the output per man during the first quarter of 1920 was nearly 22 per cent. lower than the output of 1913. This decline is due largely to the reduction in hours, and as the miners' wages have been raised, apart from the advance just conceded, by an amount at least equivalent to the rise in the cost of living, it is evident that owing to the reduction in hours and other causes the miners are profiteering heavily at the expense of other workers. With the new advance just granted their average wage will be about 180 per cent. higher than in 1913 and for this they are only supplying 78 per cent. of the amount of coal per miner; the wages per ton have therefore risen about 230 per cent.

Following upon a series of conferences, the various trade unions connected with the building trades have agreed upon the following conditions in regard to the building of houses:—(1) Guaranteed full week for all operatives engaged upon housing. No man to lose time through forces over which he has no control, such as rain, &c. (2) Every building trade worker in the Army or Navy (not being a volunteer) to be released at once. (3) That non-essential buildings be suspended, and a tribunal be set up in districts to examine all claims for building outside the housing schemes, and only by their sanction shall any such building proceed. Building trade unionists to have 50 per cent. representation on such tribunals. (4) The rent of any cottage or flat under the housing scheme not to exceed 10*s.* per week. (5) That the Rents Restriction Act be extended until the supply of houses is equal to the demand. (6) In the event of the supply of labour being insufficient to meet the need, the unions are prepared to consider the permitting of overtime upon housing schemes only, but, as a condition of such consideration, every man must be employed. In other words, the unions will not sanction overtime for any man whilst other men are unemployed.

A national conference of delegates of unions affiliated to the National Federation of General Workers was held last Friday in London, when it was decided to put forward early in May the following applications for advances in wages:—20*s.* per week for all adults, men and women, and 10*s.* per week for all under 18 years of age, on the rates obtaining on June 1, in the engineering, shipbuilding and ship repairing trades, the workers between 18 and 21 years of age doing men's work to be paid the adult rates. The same application is to be made in regard to all other trades. For women in the engineering and shipbuilding trades, application will be made for a 10*s.* per week increase for adults, and 5*s.* for those under 18, as from March 31, to level up both the previous engineering and shop repairing trades award.

On page 510 of our last issue we gave further information with reference to the difficulty which has arisen in the cotton trade. Since then, the spinners have withdrawn the third clause of their demand, to the effect that any agreement arrived at should only be provisional, the operatives reserving the right to repudiate such agreement in the event of any other section of workers being granted more favourable terms than those which might be embodied in such provisional agreement.

The issues as they now stand, and covering the three sections of the cotton trade, are defined by *The Manchester Guardian* as follows:—

Spinners.

Operatives' Claim.	Employers' Reply.
(1) Advance on current wages of 60 per cent.	(1) No agreement on this basis possible, as claim is excessive. Government arbitration offered.
(2) Payment of full spinning rates for the annual summer holidays.	(2) Cannot agree to this.

Cardroom.

Pre-war standard rates to be doubled, 75 per cent. of the figure thus produced to be added. This is equal to a 65 per cent. advance on current wages.	Government arbitration offered. Claim excessive.

Weavers, &c.

60 per cent. advance on current wages.	55 per cent. offered on standard price-list rates. This offer, which is equal to 22½ per cent. on current wages, is subject to tapers, drawers, sizers, &c., accepting an advance of only 27½ per cent. on standard price-list rates.

Conferences have been held throughout the Lancashire cotton district and a ballot is to be taken of the spinners and cardroom operatives for or against

handing in strike notices, to take effect in the first week of May. The operatives are said to be determined not to accept the employers' offer of submitting the demands to Government arbitration.

With reference to this difficulty in the cotton trade, we may note here that Sir C. W. Macara has suggested that any advance of wages given now to the Lancashire cotton operatives should be given in the form of co-partners' shares, and he instances the case of the Bradford Dyers Association, who out of a three years' profit of 1,000,000*l.* have set apart 470,000*l.* for employees. "The plain fact of the situation of the cotton industry to-day," says Sir Charles, "is that we are drifting to a very grave crisis. So far the only constructive proposal made has been the one I have put forward. It cannot hurt trade unionism, since the trade union leaders would be in a more responsible position than ever, having to follow the money invested in the industry on behalf of their members. The scheme would meet a crisis in the industry; it would help to find the large amount of extra capital necessary for meeting the enormously enhanced values of the day; and it would give the workers a position and power in the industry they have never before occupied. Further, unless the workers take a share in finding capital for the industry, I do not see, in view of the obvious signs of exhaustion in outside sources, how the best use is to be made of the opportunities which are awaiting us in so many directions. There are, I know, schemes already in existence in individual mills, but the idea of the partnership of the workers should be carried out throughout the whole industry, and should be as rigidly and exactly adhered to as the wage lists. Only in that way can we avoid a state of things in which great and fatal inequalities between different concerns in the industry will produce a vicious and unhealthy competition."

The Ministry of Labour state that in most of the principal industries employment was good in March, and better, on the whole, than in February. The percentage unemployed fell during the month from 4·4 to 3·6 among workpeople (skilled and unskilled) in industries covered by the Unemployment Insurance Acts and from 1·6 to 1·1 among the members of certain trade unions (mainly of skilled workmen) from which statistics are obtained. The number of men and women on the live registers of the Employment Exchanges at April 1 was 337,854, a decrease of 66,071 on a month earlier. The decreases were largely due to the improvement in the engineering trades, following upon the recovery from the effects of the recent dispute at the iron foundries. At coal mines and in the metal industries employment was good on the whole. In the textile trades employment was good generally, except in the Irish linen trade, and in the clothing trades it was, on the whole, fairly good. Workpeople in the brick, cement, pottery, glass, building, wood-working, paper and printing trades continued well employed. Skilled agricultural workers were in demand. With dock and riverside labourers the state of employment varied greatly at different ports. The number of trade disputes beginning in March was 184. In addition, 58 disputes which began before March were still in progress at the beginning of the month. The total number of workpeople directly or indirectly involved in all these disputes, new or old, was about 134,000, as compared with about 110,000 in the previous month, and about 223,000 in March, 1919. The estimated aggregate duration of all trade disputes during the month was about 788,000 days, as compared with 450,000 days in February, 1920, and 1,139,000 days in March, 1919. The changes in rates of wages reported to the department as having been arranged to come into operation in March, with effect from that month or from earlier dates, resulted in a net increase of over 100,000*l.* in the weekly wages of nearly 340,000 workpeople. The principal increases affected tramway employees and workpeople in the paper-making, coach-building, flour milling and leather-producing industries. Changes in hours of labour arranged during March affected about 61,000 workpeople, whose hours were reduced by an average of about six per week. The principal changes occurred in the jute and lace industries. The general level of retail prices, taking into account food, clothing, fuel and light, &c., as well as rents, at April 1, was about 132 per cent. above the level of July, 1914, assuming the same quantities and, so far as possible, the same qualities of each article purchased at the present time as before the war.

Last Monday a conference was held at the offices of the Port of London Authority between a Committee of the National Council of the Port Labour Employers and of the National Transport Workers' Federation, with the object of giving effect to the report of the Court of Inquiry on the dockers' minimum of 16*s.* per day. Lord Devonport (chairman of the Port of London Authority) attended the conference, at which it was agreed to issue the following statement: "The Port Employers will accept the report as a whole, it being agreed that a joint committee of both sides forthwith work out and settle the following essential details arising out of the report: (1) To whom does this report apply—(*a*) Grades of men, and (*b*) ports; (2) Settlement of differentials; (3) Basis for revision of piece-work rates; (4) Safeguards—observance of hours of working and other agreements. Points of difference arising thereafter on the definition of grades and sections of workers, and details of working and in the actual carrying out of the agreement, to be settled by submission to an independent arbitrator agreed upon between the parties, his decision to be final and accepted by both sides, or by some other effective method to be mutually agreed upon, the object in view being the stoppage of sectional strikes."

The Joint Committee met again on Tuesday to settle points of detail, and adjourned in order to meet Sir Eric Geddes at the Ministry of Transport. It is to sit daily until all details have been agreed upon. Mr. E. Bevin said he anticipated that the committee would become a permanent body in some form.

UNIVERSITY OF LONDON, KING'S COLLEGE: SPECIAL ADVANCED LECTURES—METALLOGRAPHY FOR ENGINEERS.—We are requested to note that the first of the course of lectures on "Metallography for Engineers," by Dr. Walter Rosenhain, F.R.S., of the National Physical Laboratory, will be given on Tuesday, May 13, at 6 p.m., and not on May 6 as previously announced.

THE LATE MR. FRANK EDWARD PRIEST.—We regret to have to announce the death, which occurred on the 14th inst., at Hampstead, of Mr. Frank Edward Priest, M.Inst.C.E., Tranmere Park, Birkenhead. Mr. Priest was born on November 11, 1860. From 1877 to 1882 he served as a pupil under Mr. Beloe, and was engaged by him as an assistant, principally upon the design and construction of tramways at Wallasey, Wigan, St. Helens, Wavertree and Bootle. From 1883 to 1884 he was engaged on the Eastham, Hoolton and Childer Thornton Water Supply. Mr. Priest also carried out the Hoylake and West Kirby Sewerage Works as well as the construction of roads at these latter places. During these early periods of his career he also gained experience in the design of structures. In 1891, Mr. Priest became chief assistant to Mr. Beloe; in December of that year he entered into partnership with him and took an active part in all the works carried out by the firm. They built water works, road and sewerage works, at a number of places throughout the United Kingdom. Mr. Priest made extensive investigations on the Mersey and its estuary, and from 1894 to 1896 gave evidence thereon in Law and Arbitration Courts and Committees of both Houses of Parliament, on behalf of the Mersey Docks and Harbour Board, with reference to the Manchester Ship Canal. Mr. Priest also took a great interest in aeronautical matters, and at the time of his death he was chairman of Messrs. A. V. Roe and Co., Limited, the well-known aircraft manufacturers. He was elected a member of the Institution of Civil Engineers in 1896.

CONJOINT BOARD OF SCIENTIFIC SOCIETIES.—The third annual report for the year 1919 of the Conjoint Board of Scientific Societies, has been issued. The Committee on the Water Power of the Empire, with Sir Dugald Clerk chairman and Professor A. H. Gibson secretary, drew up a second report, in which they are able to claim that they have stimulated interest in water-power investigations in many parts of the Empire. In India, Ceylon, British Guiana, Australia, the Union of South Africa, and the East Africa Protectorate, steps are being taken by the appointment of Commissions or committees, or by preliminary investigation and survey, to estimate the water-power supplies which will be available, and in several instances the committee has been asked to give guidance and assistance. Much new development is taking place in New Zealand. A proposal has been put forward to hold an Imperial Water-Power Conference in London. Attention is drawn to the general lack of facilities in universities and technical institutes for the specialised training of young men in hydro-electric engineering. The Committee on Joint Buildings for Scientific and Technical Societies, of which Sir Robert Hadfield is chairman, has sent deputations to Sir Alfred Mond and Mr. Stanley Baldwin, in order to put forward its opinion that there is a great need for better and more centralised accommodation for the technological and scientific societies. The committee proposes to continue its effort. The Patent Laws Committee drew up a series of recommendations which were adopted by the Board and transmitted to the Federation of British Industries for use in its endeavour to introduce modifications into the new Patent Laws. Other work summarised in the report relates to such subjects as the supply of timber for aeroplanes, the establishment of geophysical and petrophysical institutes, and the place of science in warfare. The Board has also taken its share in the discussion of the formation of National and International Research Councils, and in advocating the publication of a work devoted to the Mineral Resources of the Empire. The Bulletin, which is printed and issued to the conjoint societies and the members of the Board, gives a forecast of the meetings of the societies and an early announcement of the papers to be read thereat.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Scarcity of Materials.—Genuine anxiety is apparent in manufacturing circles respecting the increasing scarcity of raw and semi-finished materials. The larger firms have great difficulty in securing full contract commitments. Makers are booked up to such an extent that it is almost impossible to place new business except at prohibitive premiums on the already unprecedented rates, while the smaller manufacturing concerns relying on merchants and contractors, are thrown upon day-to-day supplies, and are having considerable difficulty in keeping works running. At a meeting of the Federation of British Industries in Sheffield, Sir William B. Peat advised a cautious policy respecting organisation of iron and steel concerns, and said it was whispered here and there that a rationing scheme might be necessary.

Increase of Excess Profits Tax.—Commenting on the Government's proposal, Mr. A. J. Hobson, of Sheffield, president-elect of the Associated Chambers of Commerce, said the trouble about the increase was that the duty was extraordinarily unfair between firm and firm. The new tax of 1*s.* in the pound on industrial profits, if spread over the whole industry, would recommend itself as a fairer tax than the Excess Profits Duty. If there was to be a tax on industry it should be on all industry and not only on limited companies.

Iron and Steel.—The heavy engineering trades are experiencing a period of greater activity than has been known since the armistice, and this despite transport delays, wagon shortage, inadequate supplies of basic materials, and, in some cases, restricted output. Business in railway axles, tyres, wheels, engine tubes and constructional steel has improved considerably both on home and export account. Colonial purchases of railway steel have increased greatly during the past few months. There is also a larger demand for shipment respecting high-speed and other special steels, and makers of steel alloys are in a better position than they have occupied since the end of the war. British corporations are coming forward much more freely with orders for rolling-stock and material for renewals and repairs. One Yorkshire corporation has intimated its intention of setting aside half-a-million pounds primarily for the purchase of new vehicles. A certain number of these are to be the latest type of trackless motor 'buses. The pressure on mild steel products, and on plate sheets and wire rope, is intense. There are signs of German competition for foreign orders in the East, but that competition is so far insufficient to affect British prices. One of Sheffield's largest engineering firms is developing the production of motor car frames on a large scale. The problem of securing sufficient skilled labour for this and other technical work is causing some anxiety.

South Yorkshire Coal Trade.—Engineering firms and iron and steel works are making strong complaints respecting the deficiency in contract supplies. The big fuel-consuming departments have difficulty in maintaining regular working at the current rate of delivery. In many cases they have made serious inroads into emergency stocks. Unless the position improves, it is not unlikely that works will be compelled to restrict production. The shortage of melting coke and gas nuts is also handicapping industrial users. In the house-coal market there is still a large accumulation of orders. Wagons are being held up an inordinate length of time. Many privately-owned vehicles have not put in an appearance at local depôts since the holidays. All qualities of coke are scarce. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Conditions in the Cleveland pig-iron trade do not improve. Supplies still fall very considerably short of requirements and distribution is most seriously hampered by the truck shortage. Pressure on the railways is being relieved by traders making more and more use of steamers for delivery to home customers, and nearly all the iron going to Scotland is now being sent by sea, but still the railways are quite unable to deal with the demands made upon them. A general feeling prevails that prices of Cleveland pig-iron will be further advanced in the very near future, and makers are inserting a protecting clause in contracts requesting customers to pay quotations ruling at the time of delivery. It is difficult to purchase iron for export, even to the Allies, as home needs are such that they could easily absorb the whole of the output. For home consumption, No. 1 Cleveland pig-iron is 212*s.* 6*d.* and No. 3, as well as the commoner descriptions, is 200*s.*; while the quotations are 217*s.* 6*d.* and 205*s.*, respectively, for shipment to France, Belgium and Italy.

Hematite Iron.—Very little new is ascertainable concerning East Coast hematite. Makers are generally well placed, and are not pressing sales, and merchants have little iron to dispose of, so that opportunity for trading is very limited. No. 1 is 262*s.* 6*d.* for home use, and 267*s.* 6*d.* for export to France, Belgium and Italy, and mixed Nos. are 260*s.* for home purposes and 265*s.* for despatch to the Allies.

Foreign Ore.—An unsteady and certainly easier feeling prevails in foreign ore, and falling freights favour the

view of buyers that values will be lower, but several sellers still cling to the hope and belief that they will be able to put business through on substantially higher terms than the latest transactions recorded, viz., 49*s.* for rubio, of 50 per cent. quality, on the 17*s.* freight parity, Bilbao–Middlesbrough, which makes the ex-ship Tees value of best rubio, 65*s.*, as the steamers from the Spanish ore port are now being chartered at 33*s.* Consumers are again carrying rather considerable stocks of foreign ore, and at present, are not keen buyers.

Coke.—Coke keeps scarce and stiff. Average blast-furnace kind is 55*s.* 6*d.* at the ovens, and low phosphorus quality is 58*s.* at the ovens.

Manufactured Iron and Steel.—The finished iron and steel industry presents no new feature of moment. Manufacturers are too full of work, and too much in arrears with deliveries to entertain new business to any extent. The huge stocks of steel cannot be dealt with owing to lack of transport facilities, and this while customers are clamouring for supplies against contracts. Common iron bars are 26*l.*; marked bars, 28*l.*; steel ship, bridge and tank plates, 22*l.*; angles, 21*l.* 10*s.*; rivets, 33*l.*; steel boiler plates, 28*l.* 10*s.*; steel joists, 21*l.* 10*s.*; packing steel (parallel), 18*l.* 5*s.*; packing steel (tapered), 22*l.* 10*s.*; steel strip, 27*l.* 10*s.*; steel hoops, 27*l.* 10*s.*; soft steel billets, 22*l.* 10*s.*; hard steel billets, 23*l.* 10*s.*; heavy sections of steel rails, 21*l.*; fish plates and sleepers, 26*l.*; black sheets, 45*l.*; and galvanised corrugated sheets, 56*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—There is no abatement in the demand for steel material and all classes of stuff are eagerly sought after. The present activity has never been equalled or even approached within memory, and history of a very special kind is now being made. In past years we have had periodical runs on certain lines, but never a period of activity of so prolonged or of so general a character as during recent months. One point worth noting is that the end of the prevailing conditions is not within sight and buyers are anxious to fix up lots for delivery well into next year, and while makers are not over desirous to commit themselves so far ahead a limited amount of material has been booked well forward. The home trade is still most favourably considered, but a fair tonnage, sold to merchants a good long time ago, is now finding its way abroad at very excellent prices. Mills are all being kept running steadily, and the weekly distribution of plates is not nearly sufficient for requirements, and shipbuilders have, of necessity, to go easy. This is not a very satisfactory state of affairs when the cry for new tonnage is so pressing and builders have so much work on hand, but we are passing through abnormal times, and present conditions cannot be bettered. Sectional material is also in great demand, and there are many buyers for every ton produced. In the case of black sheets the position has not changed in the slightest degree, and makers are head-over-ears in work and have repeatedly to turn down very favourable lines which in pre-war days would have been run after. Galvanised sheets, even at to-day's extraordinary high price, are the subject of good business, both for the home market and for export. With the great bulk of to-day's output being consumed at home there is really very little material available for export, and so the general shipping trade shows no signs of opening out in the meantime.

Malleable Iron Trade.—In the malleable iron works in the West of Scotland there is a great amount of activity, and all classes of customers are pressing for delivery of their orders. Bookings in recent months were very heavy, and makers have now so many orders on hand that they are unwilling to even quote for new business. There is a large demand in the market for the agricultural industry, and other trades are alike in the request that their business may receive early consideration.

Scotch Pig-Iron Trade.—Scotch pig-iron makers continue to be as busy as ever, and the demand from consumers is still a long way greater than they can possibly meet. No. 1 foundry iron is very scarce, and is thus hampering business, and if the present output could only be increased by about 100 per cent. it could all be rapidly disposed of locally. Hematite iron is in great demand by the various steel works, owing to the large amount of steel material booked, but the supply is rather limited in the meantime. Prices remain very firm and have even an upward tendency, and it is quite within the bounds of possibility that another advance will be made in prices in the near future as on-cost charges have lately been rising. Export business is very small indeed, and much expansion in that direction is not anticipated in the near future.

General.—The engineering and allied trades are at present very busy, and a large amount of new stuff is being turned out. The difficulty in securing adequate supplies of material from the steel and iron works is somewhat retarding operations, but a certain amount of material from America has been coming in, and this has helped things along a bit. Shipbuilders are in much the same position as other consumers—plenty of work on hand, but suffering from short deliveries of steel and iron, &c. Nail makers are doing a very large trade, and have well filled order books, while a similar report comes from the tube makers in this district. All prices are very high, and as wages keep mounting upwards and fuel is likely to mark another advance shortly, increased quotations all round are anticipated in the near future.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—The outstanding event of the past week was news from Sir Thomas Watson, chairman of the Coal and Coke Supplies Committee of South Wales, to the effect that the Coal Controller proposed to reduce coal exports by about one-half. No further information of a definite character has transpired in connection with this statement, but the news was sufficient to cause something like a sensation in the coal industry, as the effects of such a proposal, if brought into practice, will be disastrous to both the local coal and shipping industries, particularly the latter. Already the quantity of coal arriving at the local docks for shipment is insufficient to keep all loading appliances fully employed, and the result is that in addition to congested docks there are nearly 100 vessels in the roads waiting for cargoes or bunkers. Some of these ships have been waiting for weeks. Typical instances are that of a steamer of 7,000 tons which waited five weeks for a cargo for Perim, a Swedish steamer which waited a month for 2,000 tons for Carlskrona and then went to Liverpool in ballast to load general cargo, and a 5,000-tonner which, after waiting a month for a cargo for Gibraltar, proceeded to South America in ballast for a homeward cargo. At the present rate exports from South Wales would amount to about 20,000,000 tons per annum compared with 30,000,000 tons in 1913, and if the Coal Controller's proposal become operative the exports would be reduced to 10,000,000 tons a year. The seriousness of the position will be realised from these details, and the only means by which such drastic restrictions can be avoided is by a substantial increase in the coal output. A number of South Wales miners have handed in their notices to terminate contracts on May 1 in connection with a dispute at the Nine-Mile Point collieries, but over half the men in the coalfield have refused to cease work in sympathy with the men directly affected, and there is a hope that the decision of the South Wales Miners' Federation to bring about a general stoppage will be abandoned though there is every probability that a number of isolated stoppages will take place. Exports of coal from South Wales last week totalled 243,335 tons, of which 181,038 tons went from Cardiff, 35,068 tons from Newport, 15,246 tons from Swansea and 11,983 tons from Port Talbot. Large quantities of coal continue to be sent to inland consumers and collieries are so full up with allocation business that they have practically no coal for disposal. Prices in the circumstances are nominal on the basis of 115*s.* for large, 107*s.* 6*d.* throughs and 95*s.* smalls.

The Iron and Steel Trades.—The Budget proposals have been the principal subject of interest, and the general opinion is that the result of increased taxation will be a further advance in the price of iron and steel, as it is recognised that the increased taxation will be passed on to the consumer. At the moment the demand for tin plates is quiet and prices have slightly eased, but makers generally are fully booked up with orders and the easiness is more nominal than real. For the basis box the price ranges from 75*s.* to 76*s.* for next month's delivery. Steel bars are firm at 30*l.* to 35*l.* per ton and galvanised sheets are steady at 56*l.* and upwards for 24-gauge corrugateds.

NEW WORKS AT PORT OF WELLINGTON, NEW ZEALAND.—The office of H.M. Trade Commissioner at Wellington informs the Department of Overseas Trade that at a meeting of the Wellington Harbour Board held recently it was decided to adopt the report of the engineer to the Harbour Board regarding the programme of future works which were approved by the Board last year. The approximate estimated cost of the works is 811,000*l.* The particulars of most of the schemes, together with full information regarding the port, are given in the Year Book of the Wellington Harbour Board, a copy of which may be consulted on application to the Shipping and Transport Section of the Department of Overseas Trade, 73, Basinghall-street, E.C. 2.

IRON AND STEEL IN CANADA IN 1918.—From a booklet recently issued by the Department of Mines, Canada, we find it stated that the actual quantity of iron ore derived from Canadian iron mines during 1918 was, with the exception of the year 1911, the lowest since 1900. During the past eighteen years the production has varied between a minimum of 122,000 tons and a maximum of 404,000 tons, and for many years has not contributed more than 5 per cent. of domestic requirements in iron. Metallurgy based upon imported ores has continued to develop, and in both pig-iron and steel attained its maximum output during 1918; it is still, however, supplying but a fraction of Canada's requirements in manufactured iron and steel products. The following figures, given in short tons, will be found of interest: Iron ore shipped from mines, 211,608; Canadian iron ore charged to blast furnaces, 96,745; imported iron ore charged to blast furnaces, 2,146,995; iron ore charged to steel furnaces, 48,599; pig-iron made in blast furnaces, 1,163,520; pig-iron made in electric furnaces, 32,031; pig-iron and ferro-alloys exported, 25,911; pig-iron imported, 67,397; ferro-alloys made 44,704; ferro-alloys imported, 35,284; pig-iron and ferro-alloy consumption, 1,316,025; pig-iron used in steel furnaces, 897,537; steel ingots and castings made, 1,873,708; steel rails made, 162,747; Canadian coke used in blast furnaces, 561,135; imported coke used in blast furnaces, 861,522; iron and steel imported, 786,097. Of 20 blast furnaces 15 were in blast in 1918 for varying periods of time. The total of 1,873,708 short tons of steel ingots and castings given above is made up of open-hearth steel, 1,746,334; electric steel, 119,130; crucible and converter steels, 8,244.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 23, at 6 p.m., General Meeting at the Institution, Storey's Gate, St. James's Park, S.W. Papers: "On the Hardening of Screw-Gauges with the Least Distortion in Pitch" (referring to water hardening) and "On the Hardening of Screw Gauges with the Least Distortion in Pitch" (referring to oil hardening), by the late Mr. W. J. Lineham, of London, Member. (Revised by Mr. G. T. White, of the Goldsmiths' College, London.)

THE PHYSICAL SOCIETY OF LONDON.—Friday, April 23, at 5 p.m., Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington, London, S.W. The Fourth Guthrie Lecture will be delivered by Mr. Charles Edouard Guillaume, Director of the Bureau International des Poids et Mesures. Subject: "The Anomaly of the Nickel-Iron Alloys: Its Causes and Its Applications."

THE ROYAL SOCIETY OF ARTS.—Monday, April 26, at 8 p.m.: Cantor Lecture, "Aluminium and its Alloys," by Mr. Walter Rosenhain, B.A., D.Sc., F.R.S., Superintendent, Metallurgy Department, National Physical Laboratory (Lecture III). Wednesday, April 28, at 4.30 p.m.: Ordinary Meeting, "Ancient Stained Glass," by Brigadier-General Charles H. Sherrill, LL.D., United States Army. The Right Hon. Lord Desborough, K.C.V.O., will preside.

THE ROYAL AERONAUTICAL SOCIETY.—Wednesday, April 28, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. A paper on "Aerial Transport from the Business Point of View" will be read by Major General Sir Sefton Brancker. The chair will be taken by Major-General Sir F. H. Sykes, G.B.E., Controller-General of Civil Aviation.

THE CERAMIC SOCIETY: REFRACTORY MATERIALS SECTION.—Wednesday and Thursday, April 28 and 29, the Spring Meeting of the Refractory Materials Section of the Ceramic Society will be held in the Central School of Science and Technology, Stoke-on-Trent; the president, Sir W. J. Jones, will preside. Wednesday, April 28, 11 a.m.: A few words of welcome by Alderman P. Elliott, J.P.; "Carboniferous Grits of Denbighshire and Flintshire," by Mr. T. A. Acton, F.S.A.; "The Refractory Materials of the North Staffordshire District," by Dr. A. Scott; "The Decarbonation of Canadian Hydro-Magnesite," by Miss E. Uren; "Determination of Zirconia," by Mr. H. V. Thompson, M.A.; Exhibition of Oil-burner from Glass Works—Sir William Jones, Messrs. J. Burton and C. Bailey. 2.30 p.m.: "Notes on the Influence of Grog in Admixture with Clay," by Mr. W. C. Hancock, B.A.; "Fused Artificial Sillimanite," by Mr. A. Malinovsky; "The Corrosion of Coke-Oven Walls II," "The Action of Salt on Silica and Fireclay Bricks," by Mr. W. J. Rees; "Some Light Refractory Products," by Dr. A. Bigot; "Psychological *versus* Scientific Management," by Dr. C. S. Myers. Thursday, April 29, at 9.30 a.m.: General Meeting. 10 a.m.: Symposium on Gas Firing, opened by Dr. E. W. Smith. The following will take part: Messrs. E. M. Myers, H. M. Ridge, Wm. Leckie, — Richmond, A. Fielding, A. Meade, S. T. Wilson, J. Dunnachie, Wm. Bayliss, C. W. Thomas, H. E. Copp, J. H. Marlow. "On the Tunnel Oven and its Development," by Dr. A. Granger, Mr. B. Moore, Mr. C. Bailey, Mr. J. Burton. 12.15 p.m.: "The Casting of Gas Retorts," by Mr. W. Emery. 2 p.m.: Works Visits. 7.30 p.m.: Evening Lecture, open to the public, "The Art of Systemised Inquiry (Research) and its Place in Industry," by Professor H. E. Armstrong.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 28, at 8 p.m., Annual Meeting at the Royal Institution, Colquitt-street.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Thursday, April 29, at 7.30 p.m., Grammar School, Chesterfield, Mr. J. J. Nicholson, on "Gas Producer Plant."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 29, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "Automatic Protective Devices for Alternating-Current Systems," by Mr. A. E. McColl, Associate Member.

THE INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' MEETING.—Friday, April 30, at 7 p.m., at Faraday House, Southampton-row, W.C. The following paper will be read: "Tidal Power," by Mr. J. E. Holmstrom.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 30, at 39, Victoria-street, S.W. 1. Social Evening; recently elected Members specially invited.

CANADIAN NATIONAL EXHIBITION, 1920.—H.M. Trade Commissioner at Toronto reports that the forty-second annual Canadian National Exhibition will be held at Toronto from August 28 to September 11, next. This exhibition affords an excellent opportunity of bringing United Kingdom manufactures to the notice of the Canadian public. Approximately 1,000,000 visitors attended last year's exhibition. Much interest in the exhibition is being evinced by French manufacturers who have applied for considerable space for the display of French products. United Kingdom firms who desire to secure space for an exhibit should apply without delay to Mr. Waters, Canadian National Exhibition, King-street-east, Toronto, Canada. Information regarding past exhibitions may be obtained on application to the Department of Overseas Trade, 35, Old Queen-street, Westminster, London, S.W. 1.

DIESEL ENGINES FOR THE TWIN-SCREW MOTOR SHIP "AFRIKA."

CONSTRUCTED BY MESSRS. BURMEISTER AND WAIN, LIMITED, ENGINEERS, COPENHAGEN.

(*For Description, see Page* 546.)

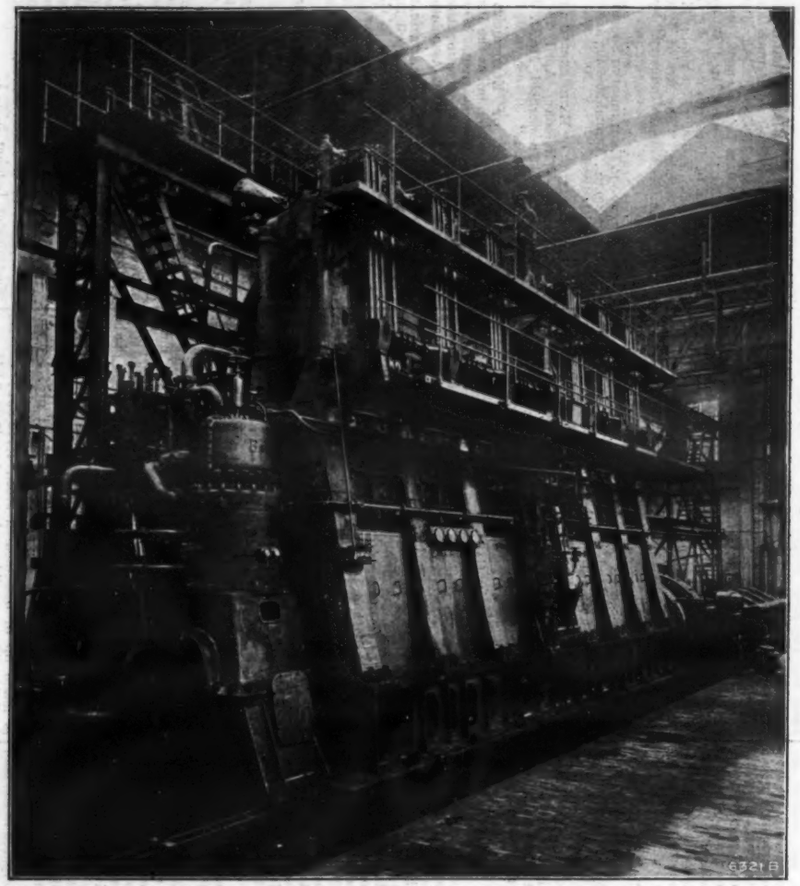


FIG. 2. ONE SET OF MAIN PROPELLING ENGINES.

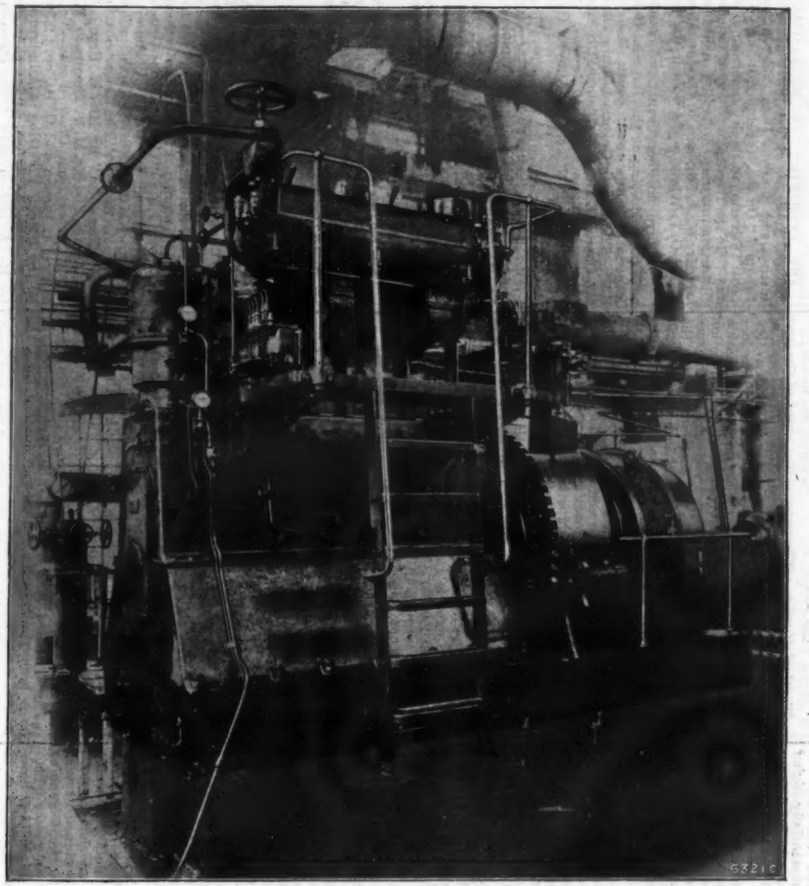


FIG. 3. 100-H.P. AUXILIARY ENGINE GENERATOR SET.

DURBAN TOWN COUNCIL.—The Department of Overseas Trade is informed that the Durban Town Council are applying to the Provincial Council for authority to borrow sums up to, but not exceeding, 263,000*l.*, to be used for the following purposes: Electric light and power, 150,000*l.*; telephone extension, 50,000*l.*; infectious diseases hospital, 25,000*l.*; Indian market, 38,000*l.*

MIDDLESBROUGH PIG-IRON SHIPMENTS.—Messrs. William Jacks and Co., 5, East India-avenue, E.C., state that the shipments of pig-iron from Middlesbrough and Skinningrove, in March last, were 14,743 tons coastwise and 19,772 tons foreign, total 34,515 tons, as compared with 12,200 tons in March, 1919, and 25,950 tons in March, 1918. There was a great falling-off in the shipments last March to Belgium and to Italy.

DIRECTORY OF PAPER MAKERS.—This directory of the paper makers of the United Kingdom for 1920, the forty-fourth annual publication, is now available at the price of 2*s.* net, 2*s.* 6*d.* post free; it is issued by Messrs. Marchant, Singer and Co., 47, St. Mary Axe, E.C. 3. The makers are arranged alphabetically according to their name, the address of the mills being given together with the class of paper manufactured. Then follow lists of paper enamellers, of representatives and agents, wholesale stationers, mills, trade designations and makes, &c.

CRYSTAL PALACE ENGINEERING SOCIETY.—The "Wilson Premium" for the best paper read before this society during the past session, has been awarded to Mr. F. S. Gill, for his paper on "Tunnels." The premium was handed to him by Sir Alfred W. Smithers, M.P., chairman of the Grand Trunk Railway of Canada, on the occasion of the 142nd distribution of certificates at the Crystal Palace School of Practical Engineering, at which he presided on April 16.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The last London meeting of the session of this Institution will be held in the hall of the Institution of Mechanical Engineers, on Wednesday, May 5, at 8 p.m., when Major B. H. Thomas will read a paper on "The Electro Deposition of Iron as Applied to Motor Vehicle Repair Work." This process was evolved in the Army during the war, and was found to result in very great economies in the saving of worn parts of vehicles, and should prove of great use in peace time. The exact processes involved will be dealt with in the paper, and the subject should be one of very great importance to the industry.

ARMSTRONG SHIPYARD; PLATE RACKS AND PLATERS' SHED.

(*For Description see Page* 540.)

Fig. 109. Plate Racks and Exterior of Platers' Shed.

Fig. 110. Interior View of Central Bay of Platers' Shed, showing Steelwork.

(*To face page* 540.)

ARMSTRONG SHIPYARD; THE PLATERS' SHED.

(*For Description see Page* 540.)

Fig. 111. Laying out Deck Plating in Platers' Shed.

Fig. 112. Interior View of Platers' Shed from Northern End.

ARMSTRONG SHIPYARD; THE PLATERS' SHED.

(*For Description see Page* 540.)

Fig. 113. Platers' Shed. Central Bay, Looking North.

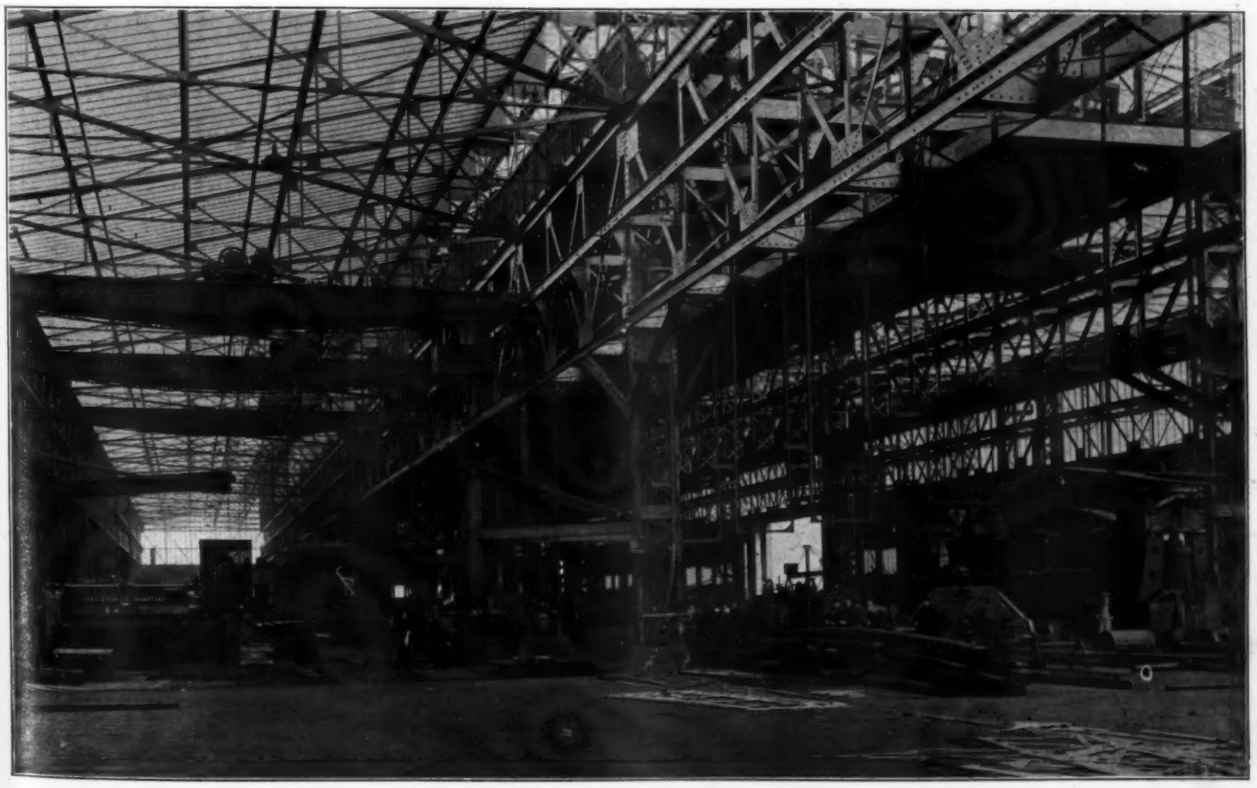


Fig. 114. Platers' Shed. Western Wing Bay, Looking North.

ARMSTRONG SHIPYARD; THE PLATERS' SHED.

(*For Description see Page* 540.)

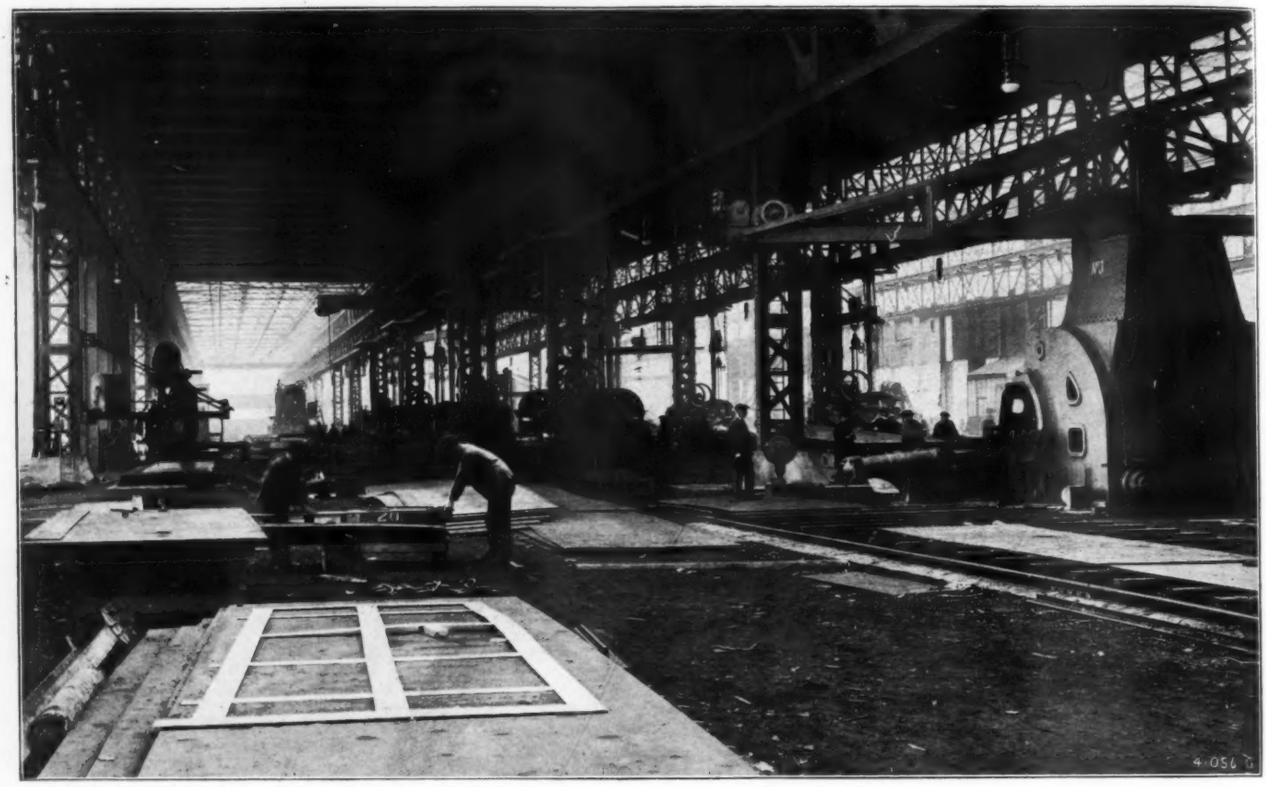


Fig. 115. Platers' Shed. Eastern Wing Bay, Looking South.

Fig. 116. Plate Bending Rolls.

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With a Two-Page Plate of the ARMSTRONG SHIPYARD.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d., post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 549.

ENGINEERING.

FRIDAY, APRIL 23, 1920.

STANDARDISATION OF SPECIAL STEELS.

EVEN before the war the use of special steels possessing special properties was making sure and steady progress. Engineers had got over their aversion to the practice of heat-treating steel before use because they could not deny the vast improvement that such treatment brought about, and because it gave to the steels to which it was applied characteristics which they desired and were anxious to obtain. And helped by improvements in industrial technique heat treatment had become an operation the results of which were sure and certain, and by experience it was found that an extremely wide range of tensile strength without any great sacrifice in toughness could, by heat treatment, be obtained from the different steels of special composition containing one or more alloying elements. The difficulty lay in the choice of type when for a given strength a wide range of steels were offered, and the engineer could not decide which was suited for his purpose, while generally he was not a little bewildered by the advice offered in copious measure by the numerous commercial advocates of their own brands out for a deal at any price. And so it ended, as it will generally end under similar circumstances, in the choice of the ordinary material the properties of which were already well known, so that its handling presented no difficulty even to the least skilled. This period of hesitating trial and pioneering was just beginning to be displaced by merited confidence when the war broke out and quickened to an incalculable degree the rate of progress. With the demand for guns, aero engines and tanks, the construction of which consumed large quantities of high tensile steel of special composition, grew a demand for steels of still higher strength and toughness, and this led to particularised research into the properties of new alloy steels and their heat treatment. Ideas were no sooner formed than they were tried in practice, failures were scrapped and successes were still further improved, and every day saw the demand for special steels grow greater as the applications of their use were extended. Men who would never have taken the risk of handling such materials under normal business conditions willingly stifled their doubts for the furtherance of a great cause and threw themselves energetically into the task of mastering their troubles and their lack of experience. And the result in most cases was brilliantly successful, while the permanent effect has been, and will be, of great value to our engineering industries since it has broadened their outlook and improved our knowledge of the properties of engineering materials. In five years of intensive effort there has been compressed it is difficult to say how many years of normal progress.

As the result of such rapid development it is not unnatural that some of the conclusions reached must be considered to be in the nature of tentative opinions, and to modify or confirm them time is necessary to test them under everyday conditions. At present the designer of any part of an engine can fix from his calculations what tensile strength the material should possess to bear the load with safety, but having fixed the strength of his steel he has the choice of several compositions of alloy steel, all of which can be made to possess this strength by heat treatment. The question as to which should be used then brings into view the measurement of other properties than strength and the share which such properties bear in the production of a satisfactory life of the part when in use. Should the elongation and contraction of the tensile test-piece be the sole guide in the decision? Or should the impact test, the fatigue range, the Stanton test, the bend test, the Sankey or Arnold form of alternate bend test, be used to discriminate. It is here that experimental work and experience are wanted to help to form a conclusion. There are many forms of special test available, but what particular property, if any, such tests measure is a difficult question to answer. The impact or notched-bar test has been growing in favour, but there are not a few who contend that the particular variety of toughness measured by this test and indicated by a high impact value does not give any indication of the usefulness or otherwise of the steel under examination, or bear any relation to the life in service. We believe, however, that this view is based on an erroneous idea of what the notched-bar test measures. When a localised stress of high intensity occurs in any steel part under load, local extension may occur and may lead also to the formation of small cracks which, once they are formed, may spread further and even lead to disaster. But the chances of a crack extending and the rate at which it will extend will depend on the energy required to separate the crystals without deforming the surrounding material contiguous to the surface of separation. If the crystal grains composing the material can be split or cleaved easily, then a crack once formed will require little further energy to cause it to spread. Now it is just this property of the crystal grains which the energy absorbed in a notched bar test measures, and since it is impossible to avoid the occurrence of localised stresses it is essential to see that if they do occur the material is in the correct condition to withstand their effects. Material which has a high impact or notched-bar value—and the term high is used here in a relative sense, since it depends on the tensile strength as well—is therefore safer to use since it is much less liable to fail under irregular stress distribution which cannot be avoided in practice.

Specifications are intended to cover the average requirements and to simplify acceptance conditions, and in the case of special steels of high strength the task of the engineer would be greatly lightened if some of the numerous testing methods were done away with and the acceptance of such steels was based on a tensile and notched-bar test only. The Air Board specifications are already in existence on this basis, and their general adoption is strongly advocated.

The largest quantities of special steels are used without doubt by the automobile trade, and a very useful contribution towards the idea of standardisation both in type and application is set out in a paper read before the Institution of Automobile Engineers by Dr. Hatfield. In great detail he has made lists of all the principal parts of a motor car engine and transmission system, and given for each part the type of steel which has been used and the type of steel which he recommends should be used. The information which is contained in these lists show to what a great extent individual choice affects the type of steel used for any particular part. Take gudgeon pins, for instance. They have been made from steel with 80 tons to 90 tons tensile, from carbon case-hardening steel, plain carbon steel, 3 per cent. nickel steel, nickel chrome steel, and tungsten steel. And then, on top of this, Dr. Hatfield recommends 5 per cent. nickel case-hardening steel. Steering pinions have been made from nickel case-hardening steel, nickel chrome case-hardening, air-hardening steel, chrome vanadium steel and even bronze. And similar diversity exists

for every part. The choice of type will depend on two factors, suitability and cost, and in general where two steels are equally suitable the cheaper steel should be used. In Dr. Hatfield's paper, however, the question of cost is not considered, and in many cases, for instance, a nickel steel is recommended where a plain carbon steel would be equally suitable and much cheaper. If a tensile strength of not greater than 45 tons per square inch is necessary, then a carbon steel will fulfil all that is wanted, and it is needless expense to use an alloy steel in such a case—always provided, of course, that strength is the main deciding factor.

But the effort to avoid confusion and to specify for each part a standardised material deserves all the support that can be given to it, not only for the automobile manufacturers' benefit, but for the steel-makers' benefit as well. There is no need to point out how standardisation in types must cheapen the cost of production, and since special steels are necessarily expensive it is a further argument in its favour. It can only be carried into effect through the combined efforts of the makers and the users, and after careful consideration has been given to the conditions of service of each part and to the extensive experience gained in the use of diverse types for the same purpose. But the time is ripe for this to be undertaken, and the paper of Dr. Hatfield focussing as it does some of the differences, comes at an opportune time.

MAN'S DISPERSAL OF INSECT PESTS.

WHEN Mr. H. Maxwell Lefroy, Professor of Entomology at the Imperial College of Science, gave a series of lectures on "Insect Pests" at the Royal Institution last year, he described the ravages wrought by locusts, weevils, boll worms, aphis, flies, &c., in plants and animals, and the ways in which these pests are being fought scientifically, and how we can protect our buildings, food, cattle and ourselves against insects. The object of his discourse, delivered last Friday at the same place on "The Menace of Man's Dispersal of Insect Pests," was different. Again, Professor Lefroy had to illustrate the destruction of orchards, grain stores, cotton and sugar cane plantations, and to speak of the remedial measures, which the systematic study of the habits of the insects had suggested, and again also one could feel—though the lecturer did not refer to this point—that the ultimate solution of the insect problems will have to be worked out by the engineer. But his main point was that the menace is increasing and not diminishing, that damages formerly estimated in millions of dollars per year have swelled into millions of pounds, and that this spreading of the menace is man's own doing. Some of these insects are formidable because they assail the individual plant or animal in swarms that kill the whole individual; others attack each grain singly, and yet are not less formidable owing to their extraordinary fecundity under favourable conditions. In some cases we can trace the routes by which they have travelled. The coffee plantations of Ceylon and India were ruined by insects coming from Sumatra and Java; the blow fly, fatal to Australian sheep flocks, was probably introduced there from this country; Egypt, Brazil, Mexico, the United States, Japan, have all originated plagues which have spread in various directions, while the sugar-cane pests of Australia and Fiji, of Natal and of the West Indies seem still to be distinct and each characteristic of the locality.

The fight against insect pests is hardly more than a few decades old. It has been taken up energetically in the United States; if little official attention is paid to entomologists in the United Kingdom, the Dominions fully recognise their utility. Why, then, is the menace increasing? Because, says, Professor Lefroy, insect pests become dangerous outside their own home centres, where the natural enemies are missing, and because increased communication facilities enable insects to find new homes. The war has made the immediate danger more grave, but is not directly responsible for it. In the olden days communication was by ship; the ships were slow, and insects did not survive the long journeys. Now ships are faster, but they still start from docks, far away from the breeding grounds of the insects. Railways come closer to those grounds, and through-carriages on interlinked railways take us, our produce and our insects right across the Continents and might soon carry us without changing from England far out to the East, into Asia and through it, and to Egypt and the Cape. Two important links in that connection were still missing, the Channel tunnel and the Gibraltar tunnel. The railway lines along the northern coast and the western coast of Africa, the Bagdad Railway, and lines joining the west of Australia to the south and east, were already complete or being built, and the aeroplane transformed journeys of days into journeys of hours, across lands and seas.

Throwing pictures of a Vickers-Vimy commercial aeroplane on the screen, Professor Lefroy pointed out what excellent accommodation and shelter machines of this class afforded also to travelling insects. When the machine landed at night the lights of the cabin attracted them, and whatever crawled on the ground found plenty of safe corners. Professor Lefroy had asked Dr. Mitchell to look out for insects on his projected aeroplane trip to the Cape. From reports available few insects seemed to have made use of that machine, but the journey had mostly been in dry heat, and white ants had been found on the machine—rather ominous! There was already a brisk aeroplane service from South Italy via Tripoli in North Africa on to Cairo, "the Clapham Junction for insect-pest distribution," and further east and south. The aeroplane brought many districts, so far separated by natural barriers, within easy communication. In Asia the barriers were mountains and deserts; between West Africa and North-West Brazil, both centres of dreaded plagues, obstacle was an ocean little crossed by shipping, but easily traversed in one morning by flying machines.

The dangers are, no doubt, real. Yellow fever—now almost confined to a few spots—malaria, sleeping sickness, typhoid, &c., are all propagated by insects and parasites, as Professor Lefroy did not fail to point out. He had, however, no remedial proposals to make. To many people a Chinese-wall policy would more strongly appeal at present than ever. People afflicted with certain diseases are already excluded from some countries. Passports and quarantum cannot be insisted upon for insects, which arrive hidden in the fruit, grain and produce we need. Scientists will further have to see how international traffic can be safeguarded without being stifled, and the engineer ought to have a large share in framing and supervising the rules.

MERCHANT SHIPBUILDING.

AN excellent indication of the flourishing condition of the British shipbuilding industry is afforded by the returns just issued by Lloyd's Register for the quarter ended on March 31 last. From these it appears that, on that date, there were no less than 865 merchant ships with an aggregate gross tonnage of 3,394,425, under construction in the yards of this country—an increase of over 400,000 tons on the corresponding figure for the December quarter, and of nearly 1,140,000 tons over the figure for the first quarter of last year. In comparison with pre-war times the present figure shows an increase of nearly 65 per cent. over the tonnage under construction in March, 1913, viz., 2,063,694 tons, which was the record figure for that period. We have also regained our position as the world's greatest shipbuilding nation, the tonnage now building in this country exceeding that under construction in the United States by 821,127 tons. The vessels launched during the quarter, however, show a distinct decrease in comparison with the figures for the December quarter. In the latter period 153 ships, making 459,354 tons, were launched, but in the March quarter only 131 launches took place, and the tonnage of these ships was 454,294. New vessels put in hand during the March quarter numbered 229, with an aggregate tonnage of 708,031, as compared with 168 vessels having a total tonnage of 603,632 commenced in the last quarter of last year.

More than a third of the total tonnage building in this country is in hand in the yards on the Clyde, Glasgow alone accounting for 199 ships, making 811,022 tons together, while Greenock is responsible for 74 ships, with a total tonnage of 367,670. The figures for both these ports show a notable increase on those for the previous quarter, the increase in the case of Glasgow being 18·6 per cent., while the increase at Greenock is nearly 9 per cent. In the Newcastle district 122 vessels, with an aggregate tonnage of 629,408, are building, the latter figure representing 18·5 per cent. of the total for the whole country. The increase in the case of Newcastle, is, however, only just over 6 per cent., the tonnage building in December having been 593,189. The Belfast and Londonderry district has the next largest shipbuilding industry, the vessels building there numbering 46 and amounting to 359,250 gross tons—an increase of 6·7 per cent in tonnage in comparison with the December quarter. At Sunderland 75 ships, with a total tonnage of 346,215, are now under construction, the tonnage being 15·6 per cent. greater than that building in December. The figures for the Middlesbrough district, on the other hand, show a slight decrease on those for the December quarter, the present tonnage of 217,790 (49 ships) being 8,130 tons less than was building at the end of last year. In the Barrow district, which includes Maryport and Workington, a certain amount of new work has been put in hand, the vessels building in this district now amounting to 14, with a total tonnage of 118,990, as compared with 10 ships, making 84,675 tons, in December; the increase in tonnage in this case amounts to over 40 per cent. An even larger percentage increase in tonnage has occurred at Liverpool, where 47 ships, with an aggregate tonnage of 107,619, are now under construction. The tonnage building at this port at the end of the December quarter was 76,380, so that the increase amounts to about 42 per cent. A slight decline in work has taken place at Hartlepool, where the tonnage building has fallen from 90,100 in December to 89,140 in March, the latter tonnage being comprised in 19 ships. At Hull the vessels building have decreased in number, from 68 to 58, during the quarter, but in the same period the tonnage has increased from 62,733 to 78,168. The mean tonnage of vessels building at this port has thus increased from 920 to 1,350.

Although none of the vessels now on the stocks is equal in tonnage to the "leviathans" built in pre-war days, there is a notable increase in the number of large ships building. Vessels in hand of 10,000 tons and over now number 62, as compared with 55 at the end of December. Of those now building 10 come between 10,000 tons and 12,000 tons, 29 between 12,000 tons and 15,000 tons, 20 between 15,000 tons and 20,000 tons, and 3 between 20,000 tons and 25,000 tons. Of the remainder 247 are over 5,000 tons and under 10,000 tons, and 285 are over 1,000 tons and under 5,000 tons.

Of foreign shipbuilding countries our most formidable rival is, of course, the United States, but the tonnage under construction in that country has fallen during the quarter from 2,966,515 tons to 2,573,298 tons, and the number of vessels in hand from 647 to 535. A slight decline in shipbuilding has also occurred in the British Dominions, in which 109 vessels, making 231,259 tons in all, are now in hand, as compared with 113 vessels, with a total tonnage of 251,480, building at the end of December last. The only foreign countries in which shipbuilding activity has increased are Holland, Italy and France. Holland has now 141 ships, totalling 366,581 tons, in hand, while Italy, which now includes Trieste, is building 165 ships, making 355,241 tons in all. Japan comes next in order of magnitude of shipbuilding work, the present figures for that country being 68 ships under construction with a total tonnage of 285,676; the latter figure is, however, 23,798 tons less than the corresponding figure for the December quarter. In France the number of vessels building, viz., 65, has not altered during the quarter, but the tonnage has increased from 216,775 to 240,225. The only other countries with vessels totalling over 100,000 tons in hand are Sweden and Denmark, the tonnages for these countries being 118,553 (73 ships) and 114,851 (62 ships) respectively. Excluding Germany, for which country figures are not yet available, the vessels building abroad number 1,340, and the aggregate tonnage amounts to 4,547,525. Adding

to these the figures previously given for Great Britain and Ireland, we get the total number of vessels building for the whole world as 2,205, and the total tonnage under construction as 7,941,950. These figures, when compared with those for the first quarter of 1913, in which the pre-war record for this country was reached, show clearly how the shipbuilding nations of the world are endeavouring not only to replace the shipping lost in the war, but also to make up for the arrested natural development which the war occasioned. At the end of March, 1913, the vessels building in the whole world numbered 1,007, and the aggregate tonnage amounted to 3,440,910, so that the number of ships now on the stocks is more than double the former figure, and the tonnage has increased by over 130 per cent. It may also be interesting to note that, of the total number of ships now under construction, only 187, with an aggregate tonnage of 140,500, are sailing ships, and that only 30 ships, making 39,613 tons together, are constructed of reinforced concrete. Of the latter class, the vessels building in this country number 11 and have a total tonnage of 4,255.

THE LATE MR. WILSON WORSDELL.

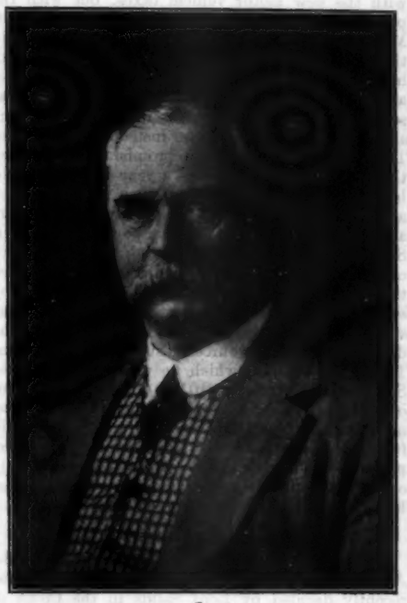
THE regretted death of Mr. Wilson Worsdell, which occurred suddenly at Ascot on the 14th inst., brought to a close a life which had a very considerable influence on modern British railway practice. Mr. Worsdell had a wide experience early in his career which enabled him when the time came to treat problems in a broad spirit.

Born on September 7, 1850, at Crewe, it is not unnatural that he early became interested in locomotive work. He came of Quaker stock, and his early education was obtained at a school of the Society of Friends at Ackworth. At the age of sixteen he returned to Crewe and entered the drawing office of the locomotive department of the London and North-Western Railway, but this was only in the nature of a stop-gap while arrangements were being made for him to go abroad. In little more than six months he was crossing the Atlantic to start as a pupil in the Altoona locomotive shops of Pennsylvania Railroad, under the then superintendent of motive power, Dr. E. Williams, who was subsequently one of the notable members of the firm of Messrs. Burnham, Williams and Co., now known as the Baldwin Locomotive Works, Philadelphia, Pa., U.S.A. Young Worsdell was with the Pennsylvania Railroad for four and a half years, returning to England in 1871, when he again entered the locomotive department of the London and North-Western Railway at Crewe. After some time there in the erecting shops and drawing office he went, at the age of twenty-four, to Stafford as assistant foreman in the running sheds, a position he retained till 1876, when he was promoted to foreman at Bushbury Junction. Two years later saw him in charge at Chester. This position he held till 1883, when he was appointed assistant mechanical engineer on the North-Eastern Railway, at Gateshead, by Mr. Alexander McDonnell, who was then the locomotive superintendent of that line.

In 1886, Mr. Thomas W. Worsdell transferred his services from the Great Eastern Railway to the North-Eastern Railway, as locomotive superintendent, and Mr. Wilson Worsdell served under his brother until the latter retired in 1890, when Mr. Wilson Worsdell was appointed superintendent. This position he retained till 1910, when he retired after twenty-seven years' service on the railway, in charge of the locomotive, carriage, and wagon departments.

Mr. Wilson Worsdell was thus connected with the North-Eastern Railway during one of the most interesting periods of British locomotive history. Mr. T. W. Worsdell, during his term of office was responsible for the construction of a large number of Worsdell-Von Borries compound locomotives. These engines did excellent work in their day, many of them holding very good records for speed and economy. They were, however, handicapped when the train loads began to mount up, and Mr. Wilson Worsdell followed his brother just at a time when this question was beginning to demand greater attention than economy. Mr. T. W. Worsdell had built several classes of four-coupled bogie engines as well as singles. His brother at first turned his attention mainly to the development of the four-coupled type, though he also constructed some notable single engines. This latter type, however, was being almost universally discarded about this time for main line work owing to the increase in train loads.

Mr. Wilson Worsdell's developments led him ultimately to the production of a very powerful class of 4-4-0 engines with cylinders, 19 in. by 26 in., driving wheels 6 ft. 10 in. in diameter, and a working pressure of 200 lb. per square inch, which, of course, is unusual in British practice. The boilers had a heating surface of 1,520 sq. ft. and a grate area of 20 sq. ft. With so high a pressure these engines were well up to any work performed by their class anywhere in England. Mr. Worsdell, however, carried matters much further. Some time after the appearance of the "Atlantic" type in this country he produced an outside cylinder class of engine of the 4-4-2 category, ranking among the largest in Great Britain, which performed most



[Photo by Elliott and Fry.

THE LATE MR. WILSON WORSDELL.

excellent work on the system, handling trains of 376 tons over 124½ miles (non-stop) at a booked speed of 52 m.p.h., on a road including many rather heavy grades. Some of these engines had two outside, 20-in. by 28-in. cylinders, 200-lb. pressure, and weighed over 116 tons. A four-cylinder compound type was also tried with cylinders 14½ in. and 22 in. by 26 in., and 225 lb. pressure.

Mr. Worsdell in fact did not abandon the compound principle without trying it out thoroughly. As an intermediate step following the Worsdell–von Borries system he had experimented with the Smith three-cylinder system, of which the inventor was one of his officials at the time. Compounding, however, on the North-Eastern has gradually fallen into disuse and has been dropped, whether of the two, three or four-cylinder type, and for Mr. Worsdell's later designs high-pressure cylinders only were adopted.

To Mr. Worsdell belongs the credit of first introducing the 4-6-0 type of engine into this country for passenger work, his first design being brought out in 1899. These engines had 20 in. by 26 in. cylinders and driving wheels 6 ft. 1 in. in diameter. A heavier and most successful class was later introduced with driving wheels 6 ft. 8½ in. in diameter. The working pressure was again 200 lb. per square inch. It was mainly because of their service on this line that the ten-wheeled six-coupled passenger type became popular in this country. Reference may also be made to Mr. Worsdell's eight-coupled goods engines, one of the first classes of this type to appear in this country, as well as his three-cylinder 4-8-0 shunting engine.

In addition to locomotive work, Mr. Worsdell took an active part in connection with carriage and wagon work, the North-Eastern passenger stock during his *regime* being kept at a high standard not surpassed by any. With regard to wagons, Mr. Worsdell was an advocate of the larger capacity types, and as is well known the North-Eastern Company has been in the vanguard of this movement. Mineral wagons built for the railway by Mr. Worsdell have capacities of 15 tons, 20 tons, 32 tons and 40 tons. The North-Eastern Company's dynamometer car designed and built by Mr. Worsdell has been of inestimable service not only on that company's system but on others to which it has been loaned, and marked the commencement of a new era in operating economics in this country. During Mr. Worsdell's time the works at Darlington were very considerably developed, and he was also concerned with the electrification of the Tynemouth branch, and many improvements in coal shipping appliances at the company's docks, &c.

Mr. W. Worsdell was for many years a member of the Council of the Institution of Mechanical Engineers and his services were much valued by his colleagues. He was a Justice of the Peace. He was very popular with his staff and the great interest which he took in his men was thoroughly appreciated by them.

VALUE IN ROADS.

THE Roads and Transport Congress of the County Councils Association, which was held in November last, is to be congratulated on its voice having reached the ear of authority. Consciously or unconsciously several of the topics then raised were brought by Sir H. P. Maybury into his paper entitled "Roads—A Review and Forecast," read before the Institute of Transport on Monday last. We need only mention, for instance, Sir Henry's reference to "regional" road authorities, which formed the subject of Mr. Rees Jeffrey's paper to the conference; to the generally voiced demand made then for better salaries for road engineers, and to the suggestions that small bodies should be grouped so as to enable competent engineers to be employed; to our own reference at the time to the fact that railway companies would not dream of developing locomotives and rolling stock without corresponding developments in permanent way; and lastly to Mr. Rees Jeffrey's estimate of the value of the expenditure of the country on repairs to roads per head of population. It is gratifying to know that the responsible head of this department in the Ministry of Transport is alive to the trend of discussion among the engineers in the country.

In addition to dealing with the cost of repairs per head of population, Sir Henry turned his attention to the capital cost of the roads. Taking the acreage represented by the surface, and assuming an average figure for cost of road construction, he placed the value of our network of highways at about nine hundred millions sterling, or about 24*l.* per head of population, the corresponding cost of maintenance being according to 1914-15 figures, about 9*s.* 9*d.* per head per annum, or one-third of 1*d.* per head per day. At this valuation the capital in our roads amounts to but two-thirds of that invested in our railways, which, however, have to provide rolling stock and terminal facilities. Sir H. Maybury says he doubts "whether from any other equally small expenditure the public reaps so large a benefit in business, pleasure, exercise and recreation." The only competition probably comes from the sea in which, as a maritime nation, we are vitally interested. There we only have to provide the equivalent of rolling stock, and terminal facilities, for the organisation of the cheapest form of transport of all, to say nothing of the facilities which the sea offers for pleasure, recreation, &c.

Mr. Rees Jeffreys, in his paper at the Transport Congress, placed the figure for maintenance at much the same level as that given by Sir H. Maybury. Regarded as cost per head, the sum is not heavy. These costs are made up of labour and material which have changed in proportion in recent years. According to Sir Henry labour (including haulage and rolling) cost about 30 per cent. of the total

maintenance cost before the war. Now with the total cost 116 per cent. higher than it was then, labour haulage and rolling costs amount to 50 per cent. of the total. Clearly, in order to obtain the best value for the money expended in maintenance, it is cheaper at the present time to go in for the longer wearing, if more costly, surfaces, in order to reduce as much as possible the labour costs in surface renewal and maintenance. It has often been pointed out that the economics of road construction involve compound factors comprising several variables, such as cost of labour, cost of preparation, cost of materials, cost of laying, durability and so on. Life is an important item and, moreover, affects the question indirectly as well because of the disorganisation of traffic during repairs. This is a very real, but practically indeterminate factor—we refer of course to small repairs, not to re-layings. The cheapest road may be one actually expensive in first cost, and as such factors as labour rise, we are coming nearer and nearer to the ultimate general adoption of high-grade formations such as those embodying asphalte or concrete, which may be expected to give better value under the stress modern traffic than patched up macadam.

The value of roads again may be referred to the traffic which will pass over them. Sir Henry presented figures in his paper showing how the value of many of our important roads in the metropolis depreciated as they neared the centre of London. In the Mile End-road a vehicular speed of 10 miles per hour is practicable until Whitechapel-road and High-street are reached, where the average drops to 6·9 miles per hour. Obviously figures of this kind enable an approximation to be arrived at for the allowable cost of improvements. The maintenance of the higher speed throughout means more service per vehicle, and actually, therefore, less vehicles, for which reason it is that towns with liberal provision of wide main streets are not troubled with congestion delays. Fixed obstructions such as, for instance, a level crossing, can be given an actual valuation as in the example taken by Sir H. Maybury in which one such obstruction to the Victoria and Albert Docks may be taken as responsible for a loss of time to vehicles appraised at 150*l.* per working day or, say, 46,800*l.* per annum. This on a 50 years' 5 per cent. basis represents the sinking fund and interest on a loan of 850,000*l.* for which sum quite considerable improvements could be carried out.

NOTES.

The Prolongation of Patents.

Section 18, sub-section 1, of the Patents Act, 1907, provided that a petition for prolongation of a patent for a further term must be presented at least six months before the expiration of the patent. Mr. William Brown, the managing director of William Simons and Co., Limited, the well-known builders of hopper barges and dredgers, obtained a patent for an invention of improvements in hopper barges and dredgers, which expired on December 28, 1916. William Simons and Co., Limited, had built vessels embodying the invention up to the beginning of the war, but in 1915 their works became a controlled establishment, and only one dredger in accordance with the patent was completed thereafter by the company. Section 7, sub-section 1, of the Patents Act of 1919, added a proviso to the sub-section mentioned above to the effect that the Court might in its discretion extend the period within which a petition might be presented. Mr. Brown wished to have his patent extended as he had suffered loss or damage owing to war, and he recently applied to the Courts, by way of originating summons, for an extension of the period within which application might be made for the prolongation of the term of his patent. The matter came before Mr. Justice Sargent last week; he decided that the language of the amending proviso to the sub-section 1 quoted was inappropriate to the present case, as the real meaning of the proviso was that the Court could allow the petition to be presented after the period of six months, but before the expiration of the patent, and that the case came under sub-section 3 of Section 7 of the 1919 Act, which was inserted to protect patentees who, by reason of the war, had suffered loss or damage. This new sub-section provides that an application by a patentee, who has suffered loss or damage by reason of the war, for prolongation of his monopoly, was to be made by way of originating summons, and in his lordship's judgment the Court had jurisdiction to hear and deal with an application for an extension of the time within which the Court was asked to prolong a patent, although the patent had expired and the application was made by originating summons. From this decision it would appear that patentees whose patents have expired during the war and who, prior to their expiration had suffered loss or damage by reason of the war, are allowed to apply by way of originating summons for an extension of the time in which they may make application for prolongation of their patent rights.

Motor Fuel Supplies.

An atmosphere of what can only be described as uneasiness characterised the speeches which were made at the Commercial Motor Users' Association annual luncheon on the 14th inst. The uneasiness was concerned, not with the price of petrol, nor yet with the new motor vehicle taxes, but with the possibility of supplies of motor fuel running out. Mr. E. S. Shrapnell-Smith, the Chairman, said that America was now exporting only one tenth of her total production of petrol to other countries, and her rate of increase of home consumption was so great that it appeared possible in a few years she might become an importer instead of an exporter The position was far from promising. Not more than 40 or 50 million gallons a year of benzol could be produced in this country, even if we stripped all the gas, and it would be at least two years before anything could be hoped for from power alcohol. Mr. Shrapnell-Smith appeared to think this last source carried the greatest promise for the future, and stated that a scheme of production had been started by some of the distilling firms. Sir Marcus Samuel suggested that the best hope for the future lay in the development of new sources of supply and new fuels. The Company with which he was connected (the Shell) had subscribed £210,000 for the endowment of chemical research at Cambridge. The endowment was to be applied to the question of liquid fuels, but was in no way restricted to petrol problems. The demand for petrol was enormously out-stepping the supply, and deliveries to the United Kingdom had more than doubled since last year.

Trade Unions and the Law Courts.

The case of Drennan and others against the Associated Ironmoulders of Scotland, which was recently decided by Lord Sands in the Court of Session, in Edinburgh, is an example of the difficulties which beset trade unionists when they invoke the aid of the law courts for the settlement of their internecine disputes. It arose over the vexed question of a holiday on May 1, 1919. The plaintiffs, who were 30 in number, were members of the Associated Ironmoulders of Scotland, and were employed in a well-known engineering establishment in Glasgow. A vote of the members of the union was taken in the shop as to whether May 1 should be observed as a holiday, and about 50 voted for the holiday and 40 against it. The moulders formed only a small proportion of the workers in the establishment, and as the works were open the plaintiffs worked as usual on May 1. For doing so they were reported to the district committee of the union, with the result that at a meeting of the committee a resolution was passed in the plaintiffs' absence fining each of them 15*s.* The plaintiffs appealed to a general district meeting, and finally to the Executive Council, but without success. Thereafter they raised an action in the Court of Session in which they sought to have the resolution declared null and void in respect of certain alleged irregularities in the procedure at the various meetings. The union pleaded, among its defences, the provisions of section 4 of the Trade Union Act, 1871. That Act removed some of the legal disabilities which previously attached to trade unions, but it was provided in Section 4 that nothing in the Act should enable any court to entertain any proceedings for the enforcement of certain trade union agreements, among which was mentioned "Any agreement for the payment by any person of any subscription or penalty to a trade union." Lord Sands, in giving judgment, said that in view of Section 4 of the Act the fine was not enforceable, whether the proceedings at the meetings were regular or not, and the committee might as well have sentenced the plaintiffs to be banished or decapitated. As the fine could not be enforced the court would not decide the question whether the procedure under which it had been imposed was in order or not. He therefore dismissed the action. This result was no doubt very unsatisfactory to the plaintiffs, because, although the courts would not have enforced the fine it may be presumed that the union has practical methods of compelling the men to pay it. Lord Sands clearly had this possibility in mind, but he said that the plaintiffs had not set forth in their pleadings any possible consequences of the non-payment of the fines, and it was not for the court to hunt through the rules of the union to find them. Even if the plaintiffs had set forth such matters it seems very doubtful if the court would have interfered, although there is a suggestion in the judgment that his lordship's sympathies were with the plaintiffs.

The New Electricity Bill.

Apparently a determined effort is to be made to extend the benefits of nationalisation to the business of electricity supply. The Bill, which provides for the creation of Electricity Commissioners and the constitution of joint electricity authorities, was passed at the end of last December, and already an Amending Bill has been brought forward by the Government. The clauses of the original Bill, which related to the establishment of District Boards and the compulsory purchase clauses, were rejected in the House of Lords, and do not appear in the Act which is now in being. These rejected clauses, however, practically constitute the new Bill, which is being brought forward. This new Bill would allow the Electricity Commissioners when, for any area, they did not consider that "the formation of a joint electricity authority" would "give proper effect to the objects of the principal Act" to establish a district electricity board. Such boards would have power of compulsory purchase over existing authorities, and they could be subsidised out of public money to the extent of £25,000,000 by the Electricity Commissioners. In view of Mr. Chamberlain's statement on Monday, £25,000,000 may appear a bagatelle to those who sit in high places, but if the scheme goes through, this trivial sum will sooner or later tend to upset the Chancellor's arithmetic. The new Act says nothing of nationalisation, but if the business of electricity supply is going to be paid for by public money, then it is going to belong to the State, and if it belongs to the State, it is nationalised. It is to be hoped that the whole Bill and particularly the compulsory purchase clauses will be very carefully examined by both Houses of Parliament.

Commercial Possibilities of Airships.

Some interesting estimates of the cost of transport by airships were given in a paper read by Air-Commodore E. M. Maitland, C.M.G., D.S.O., before the Royal Society of Arts on Wednesday last. Commodore Maitland dealt with the route from England to India *viâ* Cairo, and assumed that the journey would be completed in two stages of 50 hours each. Four airships, similar to the R. 38 now under construction at Bedford, would be required to maintain a weekly service in each direction, each ship flying for 2,500 hours per annum and having a period of three months in the shed for overhaul and repairs. An airship of the size assumed would have a length of 695 ft., a gas capacity of 2,700,000 cub. ft., and a maximum speed of 70 m.p.h., while it would be capable of carrying a load of 15 tons for 50 hours at a continuous air speed of 60 m.p.h. For the purposes of calculation, however, the speed over the ground was taken as 45 m.p.h., giving a yearly ground mileage of 112,500 for each ship. Under commercial conditions the cost of constructing four airships of the above-mentioned capacity, it was estimated, would be 800,000*l.*, and a sum of 45,000*l.* was allowed for the construction of a mooring station at Karachi. This, with a working capital of 200,000*l.*, brought the total capital expenditure to 1,045,000*l.*, and interest on this, at 15 per cent., would come to

about 157,000*l.*, or, say, 7*s.* per mile flown over the ground. The annual operating costs of each airship, allowing 40,000*l.* for maintenance, 40,000*l.* for depreciation, 9,000*l.* for crew, 12,000*l.* for gas and 30,937*l.* for oil and petrol, worked out at 23*s.* 5*d.* per ground mile. Bases in England and in Cairo, it was assumed, would be built by the Government and leased to the company at a yearly rental of 6 per cent. of the cost of construction, and, on this assumption, the total cost of running each of the bases would amount to 116,700*l.* An additional sum of 12,000*l.* would be required for operating the mooring station at Karachi, and this would bring the total annual cost of the bases to 245,400*l.*, which would be equivalent to 11*s.* per ground mile. The total cost, including interest on capital, cost of operating airships and cost of running bases, would thus amount to 41*s.* 5*d.* per mile; and as each airship would carry a commercial load of 15 tons, the cost per ton mile would be 2*s.* 9½*d.* Allowing seven passengers per ton, and assuming that 75 per cent. of the total possible number of passengers would be carried on each trip, with 1 ton of mails, it appears that the latter could be carried to Egypt in two days for 6*d.* per ounce, and to India in four and a-half days for 1*s.* per ounce. The passenger rate to Egypt would be 50*l.*, which is about the same as the first-class fare by steamer, while the journey to India would cost each passenger 100*l.*, as compared with 65*l.* to 70*l.* by steamer. The whole of the above figures, it must be remembered, are based upon the performance of a moderate sized airship now under construction, and they could certainly be greatly improved upon by employing larger vessels. With an airship of 4,000,000 cub. ft. capacity, which could now be constructed and housed in existing sheds, the above figure of 2*s.* 9½*d.* per ton mile could, in Commodore Maitland's opinion, be reduced to 1*s.* 9*d.* It is interesting to compare the above figures with those given by Captain Acland, on page 520 of our last issue, for transport by aeroplane, which worked out at 10*s.* 6*d.* per ton mile, but, in this connection, the very different conditions assumed in the two cases must be borne in mind.

Recent Advances in X-Ray Work.

The development of industrial radiography, the examination of materials by means of X-rays, proceeds at so rapid a rate that Major G. W. C. Kaye, D.Sc., lecturing on the subject at the Royal Institution on Tuesday, April 13 and 20, was able to point to several novel applications as well as to new points more of theoretical interest. Dr. Kaye had hoped to exhibit one of Professor Lilienfeld's (Leipzig) new tubes, which are provided with two cathodes; but the recent political disturbances had prevented the arrival of this apparatus. The additional cathode is at the one end of the tube; it is simply a tungsten filament which is heated by a battery current to produce a stream of electrons; the electrons pass into the strong electric field between the cathode proper and the anode to which high potential is applied in order to impress high velocity upon them. X-ray tubes of metal, tried in O. Lodge's laboratory one year after Röntgen's discovery in 1896, Dr. Kaye mentioned, had recently been made of steel with water-cooled electrodes. Coolidge himself had, within the last two months, brought out bulbs made of a heavy lead glass, which protected the operator. In general, 3 mm. of lead were fortunately sufficient to stop the rays for this purpose; but in special experiments Rutherford had penetrated 1 cm. of lead, and radiographs had been taken through 3 in. of steel, 6 in. of aluminium and its alloys and 12 in. of wood. One of Dr. Kaye's bulbs could be worked continuously at 30 milliamperes and several horse-powers without the use of a rectifier or interrupter. The rays enabled us to distinguish diamonds from paste, nickel steel from steel (though the atomic weights of iron and steel differed little from one another); they revealed the correct or faulty centring of the conductor in the insulation of cables, broken wires in the heating jackets of aeronauts, the presence of metallic impurities in mica and mica preparations, the want of perfect sphericity in the cores of golf balls, the careless workmanship of war-time boots, &c.; and were invaluable not only for the medical man, but also for the botanist and the zoologist when studying the delicate structures of plants, shells and organisms without having to injure them. Of Major Kaye's own work on the examination of aeroplanes and their timber for hidden or purposely concealed faults (plugged holes or varnished joints, &c.) in spars and rods, we spoke last year on the occasion of the Faraday Society discussion of the examination of materials. Dr. Kaye had some further interesting specimens, especially also of welds and corroded metals, to show during his lectures. The rays that penetrate through steel are not always effectively stopped by the emulsion of the photographic plate either, unless special means are adopted. The emulsion may be mixed with lead salts; the films are made double or multiple, the celluloid being sensitised on both faces and several such "duplisised" films may be used in series; the plate is backed with a heavy metal (lead, platinum) which sends its own characteristics rays back in to the film; or the plate is placed on a fluorescent screen of calcium tungstate, the bluish rays of which strengthen the photographic effect; this latter method is apt to impair the definition, but is like the others sometimes very successful. One British engineering firm, Dr. Kaye mentioned, uses directly a fluorescent screen for the examination of their articles, dispensing with photography, which is a great point, of course. In America the slow changes in crystalline structure which occur in annealed and cold-worked metals are being studied by X-rays. The finger prints of criminals are made more distinct by washing the hand to be radiographed with alcohol and then rubbing red lead on it; and the rays have disclosed cases of overpainting of "old masters." Dr. Kaye certainly presented sufficient material to justify his plea for an Institute of Radiology.

THE LATE PROFESSOR A. K. HUNTINGTON.

The past week has claimed many victims from the ranks of scientists. The news of the death of Professor J. A. McClelland, F.R.S., the distinguished Dublin physicist, came last Friday, on the day when he had been announced to discourse at the Royal Institution on "Ions and Nuclei." On Saturday Admiral Wilson, and Professor Huntington passed away. Dr. Rudolf Messel, F.R.S., in his younger days an assistant of Roscoe's, and later known as the successful manufacturer, at Silvertown, of oleum by a catalytic process of his own, died on Monday. Wednesday's papers brought news of the deaths of Admiral J. P. Parry-Jones and of Dr. L. T. O'Shea, Secretary of the Institute of Mining Engineers. We are afraid that this list will have to be extended.

About the personal life of Alfred Kirby Huntington, Professor of Metallury at King's College, London, we can say very little. He was of a decidedly reserved disposition, and his great activity in many technical institutions, several of which he helped to organise, was unknown except to those who came in personal contact with him. At King's College he was the doyen of the professorial staff, and his retirement last October, after forty years of teaching, seems to have depressed him, though this severance by no means terminated his scientific work. Professor Huntington was trained at the Royal School of Mines, South Kensington (which he left in 1877, with the diploma of an Associate in Mining and Metallurgy) and in France. Like many men of his period he was first attracted by chemical research, and worked with Guthrie on carbohydrates. Together with Professor W. Noel Hartley, he investigated the ultra-violet spectrum, and did other work in physical chemistry for British Association Committees. Before 1880 already Huntington joined Sir Charles Siemens in the study of the possibilities of electric furnaces. Their crucible arc furnace was first described before the Society of Telegraph Engineers and Huntington published in the following years, before the electric furnace attracted wider attention, several papers on the fusion of metals (including the refractory tungsten) in plumbago crucibles. At King's College, Huntington worked under Percy on gold and silver, and followed the late C. Loudon Bloxam in the professorial chair. Together with W. G. McMillan he brought out in 1882 the second enlarged edition of Bloxam's "Metals, their Properties and Treatment"; the 1897 edition of this book, by Huntington and McMillan, was practically a new book.

Huntington was one of the old members of the Iron and Steel Institute which was founded in 1869, and had a large share, twenty years later, in the establishment of the Institutiion of Mining and Metallurgy, whose President he became in due time. He was on the Council of the Institute of Chemistry in the eighties, and was interested in the foundation of the Society of Chemical Industry in 1881. Later, he retired from several of his societies, and his activity was chiefly connected with the work of the Faraday Society, established in 1903, and of the Institute of Metals which, founded in 1908, elected him President in 1913-1914, and with aircraft. His presidential address to the Institute of Metals dealt with the scope of these various societies, the overlapping of which he successfully endeavoured to prevent, and with the effect of higher temperatures on the tensile strength of copper and its alloys. The immediate cause of his research had been the explosion of a locomotive fire-box, which had been attributed to the copper-zinc stays. These stays were supposed to become brittle under the influence of vibrations and high temperature; Huntington showed that stays from a Caledonian Railway engine were still as strong as originally and microscopically unchanged after sixteen years of service, and he wrote further papers on the "Effects of Heat and of Work on the Mechanical Properties of Metals." His interest in flying grew out of his work on automobiles, the great future of which he helped to initiate. Himself a balloonist, he had been across France descending at the foot of the Pyrenees. One of the original members of the Royal Aero Club and one of the oldest aeronauts living, he frequently went up from his own shed on the Isle of Sheppey; he had a machine of his own, moreover, stabilised to his design. He presided at the Ghent meeting of the Institution of Metals in 1913, and represented the United Kingdom at the conferences of the Fédération Aéronautique Internationale. His name is connected with the "Huntington Mill," in which ore is fed into the track of heavy suspended rolls revolving in contact with a hard ring. During the war he was occupied with work on high explosives in addition to being a member of several committees.

Not easily approachable, but a man of sterling character, Professor Huntington was generally esteemed. His personal wants being small, he could make donations of books and machinery to various institutions. He was a Beilby prizeman. His end came so suddenly as to necessitate an inquest; the death, in the early morning of Saturday, April 17, was due to syncope and bronchitis. On the Thursday we may add, thanks to the courtesy of the secretaries of the Institute of Metals, and of the Farady Society, he had been discussing a paper on the recrystallisation of metals, which he was going to read before the June meeting of the Institute of Metals, and on Monday last he was expected to preside at a committee meeting of the Faraday Society, though he had telephoned that he was not feeling well. He died in his 69th year.

The Efficiency Club.—The Efficiency Club for Business and Professional Women announces a series of lectures from the 27th inst. to June 22, particulars concerning which, together with cards, can be obtained at The Triangle Secretarial Offices, 60–61, South Molton-street, W. 1. The lectures are open to men as well as to women. The Efficiency Club states that it is now actively developing the second of its objects, *i.e.*, "to form a link between women in business and the professions," the first aim being "to promote greater efficiency."

The William Froude National Tank.—The fees for work carried out at the William Froude National Tank, at the National Physical Laboratory, Teddington, will in future be on the following revised scale: For making and testing one form through a complete range of speeds, and deducing e.h.p. curves for ship, 140*l.* Modifications will be lined out, the model altered and results obtained for the new form at rates varying from 20*l.* to 45*l.*, according to the work involved. These new fees will take effect as from April 14, 1920.

Scholarships in Art, Science and Technology.—The London County Council offers scholarships in art, science and technology which provide free tuition and a grant not exceeding 120*l.* a year. These scholarships are tenable for two years and may be extended for a third year. Candidates must be resident within the administrative County of London, and must not be less than 18 years of age on July 31, 1920. They must have been in industrial employment and have been attending evening classes at a polytechnic, technical institute, or school of art. Forms of application (T2/255) may be obtained from the L.C.C. Education Offices, Victoria Embankment, W.C. 2, and must be returned by Saturday, May 8.

New Shipbuilding Yard at Algiers.—A report has been received by the Department of Overseas Trade, from H.M. Consul-General at Algiers, to the effect that a company is being formed at Algiers for the purpose of erecting a shipbuilding plant. The amount of the capital is not yet known. According to present reports three slips will be constructed at Fort de L'Eau, in the centre of the Bay of Algiers, and it is hoped during the first year of the company's existence to complete the hulls of three vessels of 3,000 tons to 3,500 tons each. As it is proposed to build the hulls only in Algiers there might, if the project is realised, be openings for British trade in the supply of engines and other fittings and materials. Further information may be obtained by United Kingdom manufacturers interested upon application to the Department of Overseas Trade.

MACHINERY AT THE BUILDING EXHIBITION AT OLYMPIA.

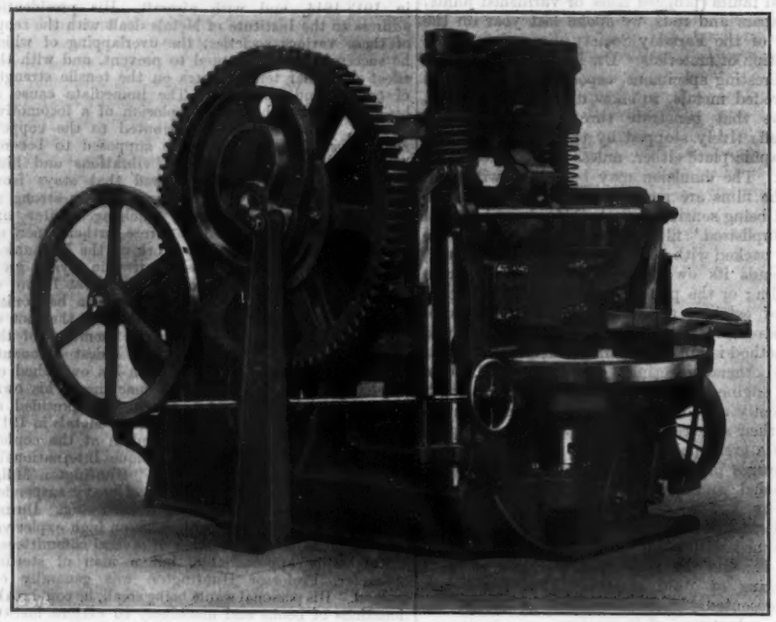


FIG. 1. BRIQUETTING PRESS; MESSRS. SUTCLIFFE, SPEAKMAN AND CO., LTD., LEIGH, LANCS.

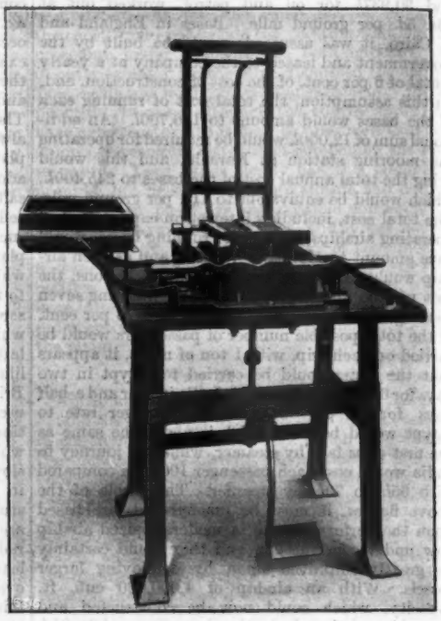


FIG. 2. CONCRETE TILE MACHINE; MESSRS. VICKERS, LIMITED, WEYBRIDGE.

THE BUILDING EXHIBITION AT OLYMPIA.

(*Concluded from page* 519.)

IN our last issue we dealt with what from a mechanical engineering point of view is the main subject of interest at the present building exhibition at Olympia—that is the various concrete block-making machines. Our treatment of this aspect of the Show was not exhaustive, however, and there are still some examples of the class with which we would wish to deal. This applies particularly to an exhibit made by Messrs. Sutcliffe, Speakman and Co., Limited, of Leigh, Lancashire. The machine shown by this firm represents an altogether different order of mechanism from the majority of the machines exhibited. We have described these latter as moulding-machines. Messrs. Sutcliffe Speakman's machine is more correctly described as a briquetting press. It is suitable for making concrete, or lime-sand bricks and also for making bricks from clays adaptable for working in the semi-dry state. The machine is equally suitable for briquetting mineral ores, flue-dust, coal, coke, &c.

The press is illustrated in Fig. 1 annexed, from which the general features of its construction will be understood. It will be clear from the figure, and from what we have already said, that the machine is of the type in which a block is formed under heavy pressure. It thus differs radically from the moulding machine class we have already dealt with. The press is furnished with a circular horizontally-revolving table which carries the moulds for the formation of the bricks or briquettes. These moulds are arranged in pairs, and, depending on their size, there are from six to eight pairs. As the table rotates and stops in its various working positions one pair of moulds is in the charging position, another is under pressure, and a third is being acted on by the ejecting ram. The feeding is automatic from a bin fixed above the table. This is not seen clearly in Fig. 1, as it is on the opposite side of the machine from that shown. The bin is fitted with revolving stirrers, and the quantity of material fed to the moulds is regulated by the hand-wheel which can be seen in the figure. This hand-wheel, and thus the amount of material fed per pair of moulds, can be regulated without stopping the machine, which gives in effect a method of regulating the final pressure on the briquettes.

Pressure is applied to the blocks from both above and below, through toggle mechanism of which the upper part is clearly to be seen in the figure. The final pressure is 200 tons. The ejector ram is actuated by a cam-operated rocking-lever which can be seen in the figure. The moulds are formed with renewable liners which can easily be replaced, and the liners are made reversible so that each gives two wearing faces. The output of the press is from 1,600 to as high as 2,400 bricks, or briquettes, per hour. It requires from 8 h.p. to 12 h.p., and is driven by an electric motor connected to the pinion-shaft at the back side. The total weight is from 15 tons to 16 tons. When the press is used for making coal or coke briquettes with pitch, or a similar binder, a heater is fitted to the feeding-bin. Finally, it should be said that the helical springs round the main columns, which can be seen in the figure, are for the purpose of balancing the weight of the heavy pressure head, and take no part in the transmission of the pressure.

In addition to Messrs. Sutcliffe, Speakman's there is another concrete block machine of the power-pressure type in the show. This is the "Manelite," shown by Mr. C. J. Mannell, of Petra Place, Poole Hill, Bournemouth, W. This machine is of the hydraulic type, and consists of a moulding box placed above a vertical hydraulic ram. The box is filled with the concrete mixture by hand, and a hinged cover is then closed down and engages a catch at the end opposite from the hinge. Pressure water is then admitted under the ram which rises, first compressing the block against the closed lid, and then automatically disengaging the catch so that the lid, which is spring-controlled, flies open. The ram then ejects the formed block. Mr. Mannell also shows a hand-power machine on somewhat the same lines. These machines, in common with others at the exhibition, produce blocks which give interlocking end joints.

In our last article we referred to some of the exhibits other than block-making machines, which illustrate the development of economical or rapid methods of building suitable for domestic and other small structures. There are others falling within this class, some of which we may mention. As an example of a type we have not yet referred to we may instance the display of the Self-Sentering Expanded Metal Works, Limited, of 2 and 3, West Street, Finsbury Circus, E.C.2. One of the most striking features of this firm's display is their "Trussit." This consists of corrugated sheets expanded or perforated, in a herring-bone pattern. With supports at 10 ft. centres the sheet may be built up into partitions or walls by filling each side with cement plaster. The form of the metal parts is such that the cement will fill up the whole of the interior and form a solid wall with metal reinforcement. A somewhat similar exhibit is made by The Expanded Metal Company, Limited, of York Street, Westminster. In this case two layers of the firm's well-known type of expanded metal are filled in from one side each with cement plaster for the construction of a cavity wall. This firm also shows the application of expanded metal to the reinforcement of brickwork by laying strips in the horizontal joints. A brick wall 12 courses deep is shown overhanging about 4 ft. Messrs. Johnson's Reinforced Concrete Engineering Company, Limited, of Lever-street, Manchester, show the same thing, the brickwork in that case being reinforced with their woven wire strip.

There are a number of exhibits of building material and fittings with the majority of which we have not space to deal. As of special interest to engineers in connection with factory building and extension we may, however, refer to a few. A fine show of their metal window frames is made by The Crittall Manufacturing Company, Limited, of Braintree. The frames, properly glazed, are shown in position in a brick building which has been erected on the firm's stand, and the effect is very good. This, however, is by no means the only stand which has been treated in this manner, and the exhibition contains many similar displays. It is, no doubt, partly owing to the subject of the exhibition which lends itself well to constructional and decorative exhibits, but it should be said that in point of general effect the exhibition compares more than favourably with the majority of the shows which are held in the same hall.

A complete cottage consisting of a timber frame covered with asbestos-cement materials is shown by the British Everite and Asbestilite Works, Limited, of 29, Peter-street, Manchester. In connection with this exhibit there is a display of asbestos-cement

MACHINERY AT THE BUILDING EXHIBITION AT OLYMPIA.

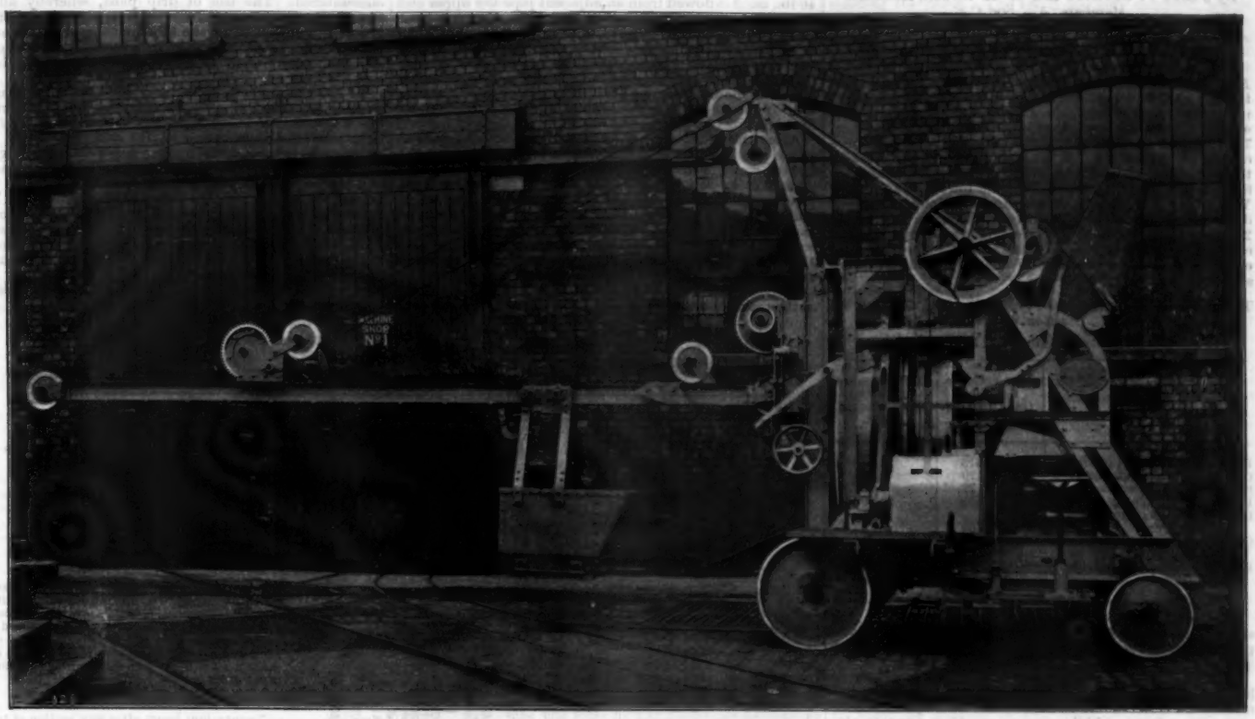


FIG. 3. CONCRETE ROAD-MAKING MACHINE; MESSRS STOTHERT AND PITT, LIMITED, BATH.

downspouts, gutters, &c., which are remarkably neatly made. Asbestos-cement building materials are also shown by Messrs. W. Pattison and Successors, of Dilton-road, Widnes, and the British Fibrocement Works, Limited, of Erith. These firms, we think, all show asbestos-cement roofing tiles of the class which is now generally familiar. Concrete roofing tiles are shown by some firms of which we may mention the Redhill Tile Company, Limited, of 17, Station-road, Redhill, Surrey. A machine for making tiles of this class is exhibited by Messrs. Vickers, Limited, of Broadway, Westminster, and is illustrated in Fig. 2 on page 556. The machine consists of a moulding box in which a pallet is placed shaped to form one side of the tile. The box is then filled in and tamped by hand, and the superfluous material is removed and the other side of the tile formed by running a shaped striker the length of the box by hand. A box with a wire gauze bottom, carried on swinging links at one side of the machine, as shown in the figure, is then moved over until it lies above the formed tile. This box contains colouring material—red oxide of iron, we believe—of which a small quantity falls on to the surface of the tile to tint it. This colour is then rubbed in by the striker and a former, which stands up behind the box and can be seen in the illustration, is brought down on to it. This forms the end of the tile with a lock, so that when erected in place it will interlock with the one next to it. The tile is then complete and is removed from the box by the treadle operated ejector.

The other illustration which we publish—Fig. 3 on the present page—shows an interesting concrete road-making plant which is exhibited by Messrs. Stothert and Pitt, Limited, of 38, Victoria-street, S.W. 1, and Newark Works, Bath. This exhibit would not appear to come specifically within the terms of the word "building," but it is to be seen at the exhibition, and we are glad to have an opportunity of dealing with it. The machine constitutes a self-contained, self-propelled concrete-mixing and spreading plant, and is particularly intended for the making of concrete roads. It consists of a carriage mounted on road wheels of which the front pair are arranged to swivel for steering, being operated by gear from the driver's platform. The carriage carries a concrete mixing-drum which has a capacity of 10 cub. ft. per mix. The shell of the drum is set in a single cast-iron ring which carries both the track for the supporting rollers and the teeth of the driving-gear. The central drive prevents torsion of the drum and undue wear of the teeth and rollers. The machine is fitted with a loading skip large enough to contain a full unmixed batch of material. It runs on a frame built up of steel sections and incorporated in the main frame of the machine. The frame is fitted with cast-iron switches arranged to tip the skip as it moves upward on the curved guides. The skip is lifted by a steel wire rope from the engine. The hoisting barrel is operated through a cone clutch working in an oil bath, and operated from the driver's platform. A brake is fitted, and a safety cut-out gear to prevent the skip over-running. A water tank of 18 gallons capacity is fixed on the main framing. The supply to the mixing-drum is controlled by a chain from the driver's platform.

To empty the mixer a discharge spout is provided, which projects into the drum. The mixed material falls from the blades on to this spout and flows either to the distributing skip or into a wheelbarrow as may be required. The skip, as will be seen from the figure, works on a swinging boom. It is built of steel plates, and is suspended from a trolley with gun-metal bushed rollers working on the boom. The bottom of the skip is in halves and hinged to the sides. It is held closed by chains and levers, and the load can be released in any position of the skip through a trip gear operated through a wire rope. The bottom doors automatically close when the skip returns to the mixer. The skip is traversed along the boom by means of a wire rope connected to a grooved racking-drum. The drum is driven through reversing clutches to allow of traverse in either direction. The boom, which is made from a rolled steel joist, is arranged either to swivel or swing. Its maximum inclination is about 20 deg., and the total angle of swing is about 140 deg. Its outer end is supported by a wire rope carried to a pulley at the top of the main frame and connected to a drum which is arranged to be operated by hand. The drum is fitted with a locking device.

The whole machine is driven by a twin-cylinder vertical petrol engine of Messrs. Lister's make. It develops 10 h.p. and runs at 500 r.p.m., and drives the mixer through machine-cut spur-gearing and a Ferodo-lined clutch. A further clutch mechanism serves to connect the self-propelling gear. This is intended for moving the machine short distances when it is at work, and is not designed for traversing it from site to site. The speed of travel is about 150 ft. per minute, or 1¾ miles an hour, and the machine is capable of climbing a gradient of 1 in 50.

ACTIVATED SLUDGE AT WITHINGTON, MANCHESTER.—After experiments, a continuous-flow plant to treat 250,000 gallons of sewage per day on the activated sludge system was installed at the Withington Sewage Works of the Manchester Corporation, in October, 1917. When described by Dr. Edward Ardern before the Society of Chemical Industry at Manchester last December, the plant had been in successful operation for two years, and no trouble had arisen, except an occasional bulking of the sludge in circulation. The plant consists of an aeration chamber, 100 ft. long, 22 ft. wide, 6 ft. deep, so subdivided by four walls as to form a channel, 4 ft. wide, 500 ft. long; the capacity is 55,000 gallons. The floor is constructed on the ridge and furrow system, the diffusers, 1 ft. sq., being placed in the furrows transversely to the flow; the net ratio of the diffusion area to the tank area is 1 : 10. Air is supplied at 3·1 lb. per square inch by a Reavell compressor. The settlement tank is pyramidal, 25½ ft. by 26½ ft. in plan, 23½ ft. deep from water level to apex, the slope of the sides being 60 deg. to the horizontal. The mixture of effluent and sludge is discharged through a 15-in. pipe within a guard chamber, and falls into a bucket suspended from the top of the pipe. The final effluent leaves the tank over four corner peripheral cells, while the sludge is discharged, by hydrostatic head, from the apex through a 6-in. pipe to a chamber fitted with diffusers to be returned by air lift to the aeration chamber. At first 100,000 gallons of sewage were treated in 15 hours (6 a.m. to 9 p.m.) per day; the charge was later increased. The diffusers had not become clogged, and only 8 of the 300 diffusers had required to be cleaned, and none to be renewed. The sludge, greyish-brown in colour, of the smell of sea weed, contains about 99·5 per cent. of water; roughly dried on hot plates it has answered as fertiliser in some experiments. Unfortunately, Dr. Ardern had little to say in his paper about the main problem extant, namely, the utilisation and dehydration of the sludge.

GROUTING OPERATIONS, CATSKILL WATER SUPPLY.*

By JAMES F. SANBORN and M. E. ZIPSER, Associate Members, Am. Soc. C.E.

(*Continued from page 527.*)

SPECIAL FEATURES IN CONNECTION WITH GROUTING.

Time Required for Grouting and Quantity of Grout Placed.—The time required for grouting the pressure tunnels varied, depending on the method and equipment used, the length of haul, the extent of the space grouted, and the quantity and distribution of inward leakage. Table I and the following data give the progress, force employed, power consumption, and other facts relating to the grouting in the 2 miles of tunnel included in Section 8 of the City Tunnel, in the lower part of New York City. This portion of the tunnel was comparatively dry, there being no large, concentrated flows within the 2 miles. The air used for grouting was supplied by a compressor at the top of one of the shafts. The plant and equipment used for grouting on this part of the work are shown in Fig. 3.

TABLE I.—*Data on Pressure Tunnel Grouting, Contract 67, Section 8.*

(Finished Diameter of Tunnel, 11 ft. and 12 ft.)

—	Low-Pressure Grouting: One Grouting Outfit.	High-Pressure Grouting: One Grouting Outfit.
Linear feet of tunnel grouted ..	10,313	13,313
Connections to grout pipes ..	170	1,683
Eight-hour shifts worked ..	72	116
Batches of grout placed ..	23,298	2,888
Quantity of liquid grout placed, in cubic yards	1,761	153
Quantity of grout per linear foot of tunnel, in cubic yards	0·17	0·02
Progress per week, in linear feet of tunnel	2,690	1,467

The total force employed in the tunnel and on the surface, averaged 42 men on each shift during the low-pressure grouting and 34 men per shift on high-pressure grouting, for two grouting outfits.

The electrical power consumed by the compressor, hoist, lighting, pumps and tractors aggregated approximately 7,800 kw.-hours and 5,300 kw.-hours per 1,000 ft. of tunnel on low and high-pressure grouting, respectively, covering two grouting outfits.

The cost to the city, of grouting, based on contract prices, averaged 5 dols. per linear foot of tunnel, on Contract 67.

Quantity of Grout taken by Flowing Pipes.—The quantity of grout injected into the pipes varied, depending on the flow of water, the size of the openings in the rock, the back pressure, and other conditions. The quantity of water issuing from a flowing pipe gave some indication of the quantity of grout the pipe would take, but it was not an absolute index. An idea of the quantity of grout taken by flowing pipes is furnished by the experience in grouting seams in limestone in the Rondout Siphon, where the tunnel lining was ruptured on account of movement in the surrounding rock when the tunnel was first filled with water for the purpose of testing it. Holes were drilled through the lining into the rock, and the seams were grouted. A very thin grout was used—about 0·8 lb. of cement to 1 gallon of water.

In the case of 29 pipes flowing less than 1 gallon per minute, only 6 took more than 1 bag of cement, and the maximum in any one pipe was 2½ bags. Of 24 pipes leaking from 1 gallon to 5 gallons per minute, the maximum quantity of grout injected into any one pipe was 24 bags of cement, the minimum, ¼ bag, and the average 4·3 bags. Of 12 pipes leaking from 5 gallons to 10 gallons per minute, the maximum quantity injected into any pipe was 7½ bags, the minimum 1 bag, and the average 3·2 bags. Of 8 pipes leaking more than 10 gallons per minute, the maximum quantity injected into any one pipe was 198 bags, the minimum 5 bags, and the average 62 bags. (See Fig. 5, page 561.)

Cut-off Walls.—The method of grouting originally contemplated called for the construction of masonry cut-off walls to be built over the tunnel arch tight against the roof, at intervals of about 50 ft. The purpose of these walls was to confine the flow of grout and to grout the space above the tunnel arch in short stretches, the pressure in the stretch grouted being raised gradually until the maximum required pressure of 300 lb. per square inch was reached. It was expected that the high pressures would force the grout into the seams in the surrounding rock. The cut-off walls were to be constructed so that they would retain grout under the maximum pressure.

In the beginning efforts were made to build these cut-off walls, but, after some experience, it was found to be impracticable to make them tight against the high pressures. Aside from this consideration, there is serious objection in the case of wet stretches to dividing the arch into short sections and at once applying high-pressure grout. If the ground-water is confined, the head builds up, and on the application of high-pressure air to the liquid grout over the arch, the ground water will force an outlet into the tunnel through the transverse construction joints in the arch. Efforts to stop such leaks by drilling holes in the concrete lining and rock and subsequent grouting were generally unsuccessful.

After the originally contemplated method of building the cut-off walls was abandoned, an attempt was made to build grout cut-off walls and to grout in three stages, substantially as follows: A connection was made to a pipe set at a low spot in the roof profile, and grout was forced in under low pressure, generally from 30 lb. to 40 lb., until it flowed from an adjacent pipe the upper end of which was at a higher elevation. Another low spot in the roof, about 75 ft. to 100 ft. distant, was then grouted, and the process was continued throughout a stretch of tunnel. If any weepers showed grout during this stage, they were plugged, and the holes were reopened about 12 hours later by cleaning out the pipes with a rod. Subsequently, connection was made at these holes for high-pressure grouting.

After the grout cut-off walls had set up, the second stage consisted in grouting the sections between the cut-off walls, starting with a pressure of 100 lb. and raising it to 300 lb. per square inch. The high vent pipes were then opened and the water that had accumulated was allowed to run off. After a stretch of tunnel had been grouted in this manner, all the valves at the ends of the pipes were opened, all plugs removed, and all pipes which were open and flowed water, were grouted under a pressure of 300 lb. After this method of grouting had been tried, it was found that more than 70 per cent. of the total quantity of grout placed was used for forming the cut-off walls. There was, therefore, little or no advantage in this scheme, and it was abandoned, and the method of grouting the entire space above the arch in one operation without the use of cut-off walls as already described, was adopted.

A fair degree of success was attained in the use of cut-offs in one stretch in the Rondout Tunnel, where the shrinkage space between the concrete in the arch and the rock in the roof at the end of each section of arch was packed tight with mortar. The method of grouting was to fill the space above a section of the arch with 1 : 1 grout at a pressure of about 50 lb. per square inch., and, after this space was filled, to continue forcing neat cement grout through the same connection until the hole refused to take grout at 300 lb. pressure. High vent pipes in the same section of arch were then grouted under a pressure of 300 lb. per square inch. The conditions in the stretch where this method was used were very favourable, the arch being practically dry and the breakage in the roof regular. Not all the cut-offs proved to be tight, however, and the grout was not confined in all cases. An interesting test, showing the reduction of tank pressure, was made during the grouting in this stretch. With an air pressure of 300 lb. per square inch at the grouting tank, a gauge at a distance of 15 ft. from the pipe connected to, registered a pressure of 160 lb. per square inch, the 1 : 1 grout over the top of the arch having been in place less than 4 hours.

In stretches of tunnel where dry packing was used above the arch continuously for several hundred feet, cut-off walls were built at intervals of from 75 ft. to 100 ft. to avoid the flow of grout for very long distances, and to prevent the separation of the sand and the cement. Brick cut-off walls were built in connection with the grouting of the wet stretch on the incline north of Shaft 4, Rondout Tunnel. The grouting of this stretch is described in detail later.

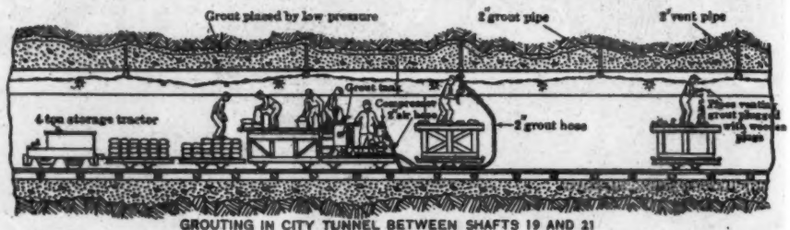
Drip Pans versus Deep-Seated Pipes.—There may be a difference of opinion as to the best method of treatment in taking care of incoming water and subsequent grouting where the leakage into the tunnel extends over a considerable area. Although in numerous cases deep holes were drilled into the water-bearing seams to collect the water, it was not the general practice to drill an extensive number of such holes where large wet areas were encountered. The use of drip pans, whereby all the open seams are exposed directly to the action of the grout, is believed to be the best method of treatment in such cases. In either method, penetration of the grout is probably very slight in the case of small openings in the rock.

In two cases where excessively wet stretches of tunnel were encountered, namely, in Rondout Tunnel, north of Shaft 4, and in the City Aqueduct Tunnel, near Shaft 24, light steel shells consisting of ribs and plates were used to protect the concrete during placing. (See Fig. 4.) The space between the shell and the rock was dry packed and subsequently grouted. In addition, holes were drilled directly into the seams and grouted. Very successful results were obtained by the methods adopted in these two stretches. There were other places where deep holes were drilled in wet ground and grout forced in the rock with very good results. Where conditions are favourable, that is, in porous and broken-up rock with open and distinct seams, permitting the free circulation of the grout, deep-seated pipes are undoubtedly very effective in grouting the rock. A sufficient number of deep holes should be drilled, however, so as to intersect as many seams as possible.

For a short distance south of Shaft 14 in the City Tunnel, practically the whole face of the rock was dripping water. To avoid covering the entire area with drip pans, parallel strips of pans about 2 ft. wide and a few feet apart were placed around the upper half of the tunnel. It was thought that the water would find less resistance in travelling through a few feet of fissured rock than through the newly placed concrete lining. This proved to be the case, as all the water came through the grout pipes connected with the pans. Through these same pipes the tunnel was grouted very successfully.

To test the efficacy of the grouting of the rock by means of deep-seated pipes, test holes were drilled through the concrete lining in the Rondout Tunnel and into the rock in the very wet stretch. With one exception, the holes showed a slight seepage, indicating that the grout had filled the water-bearing seams adjacent to the tunnel. In one hole, however, drilled about 8 ft. into the rock in the invert, a flow of 71 gallons per minute was struck, although 133 bags of cement had been forced into a hole about 5 ft. away during the original high-pressure grouting. This test shows that the character of the rock, the nature and size of the openings, and other conditions must be carefully studied in locating the holes for grouting. Another requisite for success in grouting the deep-seated pipes is the use of thin grout. It is also important to inject the grout continuously, so that the ground water pressure will not force it back into the pipe or hole.

Deep holes drilled into very fine seams will ordinarily clog the seam with drill chips, making it impossible to force much grout into such seams. Experience showed that not more than one pipe in ten would permit the grouting of fine seams. Deep holes are preferable to shallow holes, as the former are more apt to intersect water-bearing seams and take more grout. If deep-seated pipes are used along a large water-bearing seam, they should be placed generally not more than 15 ft.



GROUTING IN CITY TUNNEL BETWEEN SHAFTS 19 AND 21

GENERAL DESCRIPTION

The operation of grouting the tunnel was divided into two distinct stages: Low-pressure grouting and high-pressure grouting. The object of the former was primarily to fill the space at the top of the arch left by the shrinking of the concrete away from the rock and to fill openings at joints and honeycombed places. The object of the latter was to fill open seams in the rock surrounding the tunnel and all pipes and pans placed to control water seeping into the tunnel.

LOW-PRESSURE GROUTING.

Each unit consisted of a grouting car equipped with two grout tanks, one cement car, two platforms on wheels, six flat cars, two electric storage tractors and three shifts of men. Air at a pressure of 100 lb. per square inch at the shaft compressor was used in the machines at a pressure of 95 lb.

SECTION

Only pipes located in the key portion of the arch were connected to in low-pressure grouting.

The grout hose was connected to pipes situated at points where the rock roof was low; pipes at high points acted as vents. As grout flowed along the top of the arch, first water appeared through joints between successive days' work and from grout pipes embedded in the arch; this water was followed by grout which became thicker and thicker and finally clogged all leaking joints. All pipes running grout were stopped with wooden plugs and the valves on key pipes were closed.

In low-pressure work the hose was connected directly to valves on key pipes instead of on the Y-branches shown. Grout was forced ahead 100 ft. to 300 ft. before the machine was moved to the end of the grouted portion. The standard low-pressure batch was 1 bag of cement, 95 lb. of sand and about 7 gallons of water. This batch made 2·04 cub. ft. of liquid grout or 1·92 cub. ft. of set grout.

HIGH-PRESSURE GROUTING.

Twenty-four hours after any section of tunnel had been grouted by low pressure, all pipes which were to be connected to were cleaned out to rock to allow effective treatment by high-pressure grouting.

Each unit consisted of one grouting car equipped with one grout tank and one booster compressor, one cement car, two platforms on wheels, three flat cars and two electric storage tractors and generally one shift of men. Air was delivered from the shaft compressor to the booster compressor, which raised the 95 lb. pressure to 300 lb.

High-pressure grouting was accomplished generally in one trip over the section of tunnel. The grout hose was connected to the pipes by a Y-branch, as shown, to allow a rod to be forced in for the purpose of freeing a passage for the grout which often became jammed in the pipes by the high pressure.

All grout pipes that were connected to had grout forced into them at 300 lb. pressure, which was maintained for 5 minutes. The standard high-pressure batch was 1 bag of cement and 5½ gallons of water, which made 1·24 cub. ft. of liquid grout or 1·2 cub. ft. of set grout.

FIG. 3. METHOD OF GROUTING IN PRESSURE TUNNEL.

* Paper read before the American Society of Civil Engineers, February 4, 1920.

apart; the seams where exposed should be raked out to clear them of loose chips of rock, and the edges should be caulked with oakum or covered by a drip pan before placing the concrete. The difficulty of adjusting the consistency of the grout, where large and small seams occur, has been referred to. Wide seams require thick grout, while fine seams are at once blocked without filling, unless the thinnest grout is used.

Time of Grouting.—The question of the time to be allowed between the placing of the concrete lining and the application of high-pressure grout was given careful consideration, particularly where the tank grouting pressure might be transmitted over a considerable area. It was stipulated in the specifications that grouting under pressure would not generally be ordered in any place until three months after placing the concrete lining at that place. This rule was generally followed, although there were cases where grouting under 300 lb. pressure was done within a month after the placing of the concrete without injury to the lining. There were two or three cases where the lining ruptured at the time of grouting, but the breaks were not due to the lack of age of the concrete. No case of cracking occurred in the top of the arch.

Other considerations controlling the time of grouting are the shrinkage and the imperviousness of the concrete. Tests show that, at the age of one month, concrete has developed 80 per cent. of its three months' strength and has acquired the greater part of its imperviousness. Shrinkage also appears to be complete in from three to four weeks. It would seem, therefore, that grouting under ordinary conditions can safely be done one month after the placing of the concrete lining.

Cracks in the Concrete Lining.—Reference has been made to the opening of the transverse joints between adjacent sections of the arch and side walls, due to the contraction of the concrete. Irregular transverse shrinkage cracks also developed between the construction joints, even in the 30-ft. and 40-ft. lengths of arch and side wall. The cracks were mostly in the arch, but were quite common also in the side wall. This cracking is due to the contraction of the concrete in cooling from a temperature of 100 deg. to 160 deg. F. during setting, to the normal temperature in the tunnel which in summer was not much above 60 deg. and in the winter sometimes fell below 32 deg. F. near a shaft.

The frequency of the intermediate cracks in the lining was affected by the time of year the concrete was placed. In the City Tunnel, for example, it was found that there were more cracks in the concrete placed during the warm summer months than in that placed during the winter. The richness of the concrete also may have influenced the cracking. There was some inward leakage through the intermediate cracks in the lining after the grouting in the tunnel was completed and the ground-water pressure had accumulated. Most of these leaks, however, silted up after some interval.

There were only two cases where the lining cracked during the high-pressure grouting. In the Moodna Tunnel, several breaks developed in one stretch in the side-wall concrete, the cracks extending in places into the invert concrete. Examination showed that the breaks in this stretch resulted from defective work in connection with the placing of the concrete lining, the defects being due principally to inadequate measures for taking care of the inflowing water which accumulated behind the forms, resulting in the formation of laitance and weakening of the concrete. In grouting the Hudson Tunnel, several cracks developed in the lining under a grouting pressure of 600 lb. per square inch. On cutting out the concrete at one of the cracks, where a large drip pan had been used, it was found that a soft deposit had formed between the pan and the rock, so that it had been impossible to fill this space effectively with grout.

Leakage through Construction Joints.—In wet stretches some difficulty was experienced in cutting off the leakage of water into the tunnel through the transverse joints in the arch. These joints opened up, due to the contraction of the concrete caused by the drop in temperature from the time of setting to the time of grouting, holes drilled into the joints through the concrete and grouted proved ineffective, as the running water would wash out the grout.

Various schemes were tried to make the transverse joints tight, among which were the following: Grouting grooves were formed at the end of each arch section, either by embedding a slit rubber hose in the concrete or by nailing a strip of sheet iron over a recess left in it at the joint. These grooves were grouted through pipes set in the concrete. The results were not entirely successful in cutting off the leakage. Better results were obtained by the use of steel plates embedded in the arch joints, the purpose of the plates being to provide a water stop as well as to retain the grout. These schemes were used only to a very limited extent at the beginning of the work, and, later, were abandoned.

Very good results were obtained in closing wet transverse joints by hand caulking them. Grooves about 1½ in. deep were cut along the joint and ¼-in. lead wire was hammered in. This method proved quite effective in making the joints tight.

The longitudinal joints between the invert and side walls were found to be tight. At the joint between the side walls and the arch some leakage occurred in the wet places. There was also some inward leakage in places at the longitudinal joints in the arch. The greater part of this leakage was due to porous concrete in the vicinity of the joint, where a relatively dry concrete had to be used, and part may have been the result of a slight opening of the joints due to the lateral contraction of the concrete.

Inspection of Grout in Place.—In order to see how effective the grout was in filling void spaces back of the concrete lining, test holes were cut in the arch concrete in several places in the pressure tunnels. Blocks of concrete about 1 ft. square were cut out in the arch, exposing the rock in the roof. It was found that the space between the top of the arch concrete and the rock was well filled with grout, and tests showed the grout filling to be dense and hard. As a somewhat dry consistency is used for the concrete in the top of the arch, this concrete when placed is likely to be porous in places; in the concrete cut out of the test holes, the grout was found to fill the voids in this concrete, and the entire block was a dense and uniform mass that was in solid contact with the rock. Test holes were also cut from the lining in the Rondout Pressure Tunnel where grout was used to fill the shrinkage space at the top of the concrete lining placed inside of a steel reinforcing shell. Here, also, excellent filling was found between the concrete and the steel.

Several opportunities were also afforded to observe the results of the grouting during the progress of the work. In grouting the wet seam in the Hudson River Tunnel near the East Shaft, already referred to, the seam, as stated, was found to be well filled with grout when exposed by the excavation. In sinking the wet shaft, known as Shaft 4, at the Rondout Pressure Tunnel, grouting was resorted to, as the shaft was deepened to cut off the inward leakage, and the subsequent excavation through the grouted zone showed the seams in the rock well filled with grout. The grouting in this shaft is described subsequently in more detail.

In Shafts 22 and 24 of the City Tunnel, where the wet portions were grouted as the shafts were sunk, subsequent excavation showed that all but the very fine seams were completely filled with grout.

FIG. 4. STEEL SHELL FOR TAKING CARE OF WATER, RONDOUT PRESSURE TUNNEL. FLOW OF 2,000 GALS. PER MIN. ENCOUNTERED IN STRETCH OF 350 FT.

Reduction of Inward Leakage after Grouting.—An idea of the effectiveness of the concrete lining and the grouting in cutting off leakage into the pressure tunnels is given by the data in Table II.

TABLE II.—*Leakage into Pressure Tunnels.*

Pressure Tunnel.	Length, in feet.	Leakage into Tunnel in Gallons per Minute.	
		Before Grouting.	After Grouting.
Rondout, wet stretch north of shaft 4	350	850	3
Rondout (exclusive of above wet stretch)	23,610	290	49
Wallkill	23,390	506	75
Moodna	24,100	496	85
City, wet stretch near shaft 23	90	325	8
City (exclusive of above wet stretch)	93,810	973	127

Hydrostatic Tests of Pressure Tunnels.—After the pressure tunnels and shafts were completed, they were filled with water in order to test their tightness. The tests in some cases were unusually severe, as the full ground-water head had not been restored at the time the test was made. At the Rondout Pressure Tunnel, the maximum unbalanced head at the beginning of the first hydrostatic test was approximately 500 ft. After the tests, the tunnels were unwatered for inspection and repairs, and the results were found to be very satisfactory the tunnels proving remarkably tight.

Only in four places, in the 35 miles of pressure tunnel, aggregating in length about 2,500 ft., did any weakness develop, due to the yielding of the surrounding rock, causing rupture of the lining and outward leakage and making subsequent repairs necessary. In these cases, it would have been impossible to reveal fully in advance the geological conditions, particularly where the rock appeared to be sound when the tunnel was excavated, and it is believed that no amount of grouting prior to the application of the test pressure would have been adequate to consolidate the ground sufficiently to prevent the yielding of the rock. The cost of testing the tunnels and making the necessary repairs was very much less than it would have been to make the tunnels absolutely secure by the use of steel reinforcement in the concrete lining for their entire length.

EQUIPMENT FOR GROUTING.

Air-Stirring Grout Tanks.—Tank grouting machines of the Canniff type were used almost exclusively for grouting. These machines are very simple in construction and operation, consisting essentially of a tight cylinder provided with suitable pipe connections for introducing compressed air and for mixing and ejecting the grout. The tanks are very compact, weigh about 500 lb. when empty, and have no moving parts to wear out and be replaced. They are, therefore, particularly well suited for tunnel work. Both thick and thin mixtures can be used in them, and they are equally well adapted for high and low-pressure work. They are very efficient where large quantities of grout have to be placed.

A slight disadvantage of the Canniff tank is found when grouting fine seams under high pressure, or placing small quantities of 1:1 grout. As the process is necessarily slow there is a tendency for the cement, but more particularly the sand, to settle in the bottom of the tank and clog the openings. The use of very thin grout usually overcomes the difficulty.

As a rule, two grouting tanks were operated simultaneously in grouting the tunnel, one being charged while the other was discharging. For high pressure work, however, it was the usual practice to use only one tank. The two tanks were mounted either alone on a low flat car, or at one end of a platform car which was large enough to hold, in addition, from 20 bags to 30 bags of sand and cement. In some cases, an upper platform was also provided for materials. The materials were hauled through the tunnel by mules or motor trucks. The water for mixing was measured either by pails, or automatically by a tank placed at the side or above the grout tanks. High-pressure armoured hose about 25 ft. long was used for grouting purposes. The plant used for grouting on the work at the lower end of the City Tunnel is shown in Fig. 3 on the previous page.

Operation of Grout Tanks.—The usual method of operation during low-pressure grouting was first to put into the tank the required quantity of water, then to let the air into the tank at the bottom, which agitated the water and then the cement and sand were put into the tank and stirred by hand with a wooden paddle, as it was found that the air was too slow for mixing and was also wasteful. When thoroughly mixed the door at the top of the tank was closed, the air was then admitted at the top and the liquid grout forced out through the grout hose into the pipe connected to. The air was then turned off quickly.

Unless care is taken to close the air discharge valve the instant the last of the grout leaves the tank, an after-blast of air follows the grout, resulting in stirring it up and causing separation of the materials, and also tending to form air pockets in the space grouted. The men operating the tanks, however, soon became skilled in controlling the discharge. As an added precaution the air-pressure gauge on the grout tank was closely watched to note the fall of pressure as the grout discharged, and the emptying of the tank was also indicated by the "kick" of the grout hose when the charge left it.

In some cases the following scheme was tried. The air valve was closed as the batch of grout started to leave the tank, permitting the air in the tank to expand and force the grout through the hose. This method, however, was slow and was not generally used. Where the grout displaced water the ejection of the grout by expanding the air in the tank was quite effective in cutting down the after-blast of air. The tanks could be operated very rapidly. As much as 1,500 batches of 1:1 grout, equivalent to about 115 cub. yards, were placed in 24 hours, using two tanks. This process involved the handling of about 135 tons of cement and sand in the 24 hours.

High-Pressure Air Compressors.—The air for operating the grout tanks was obtained by connecting to the air line laid in the tunnel, the air pressure in the line being usually from 80 lb. to 100 lb. In order to provide the pressures required for high-pressure grouting, small Westinghouse direct-acting single-stage air compressors, known as "boosters," were generally used. These compressors, mounted on the same car with the grout tanks, took suction from the main air line and delivered air in the tanks at a pressure of 300 lb. per square inch. The compressors weigh about 500 lb. They are provided with air gauges registering up to 450 lb. per square inch. A spring relief valve, capable of being set at any pressure up to 400 lb. is placed on the main discharge. Each branch of the 2-way discharge is supplied with a stop valve, a check valve and air emergency stop valve, so that it may be closed automatically by a sudden release of pressure due to the bursting of hose or any other reason.

Independent Air-Generating Plant in Tunnel.—The grouting in the tunnel necessitated the maintenance and operation of the large compressor plant used for tunnel driving, and the relaying of the air pipe line in the tunnel, which had been taken up during the placing of the lining. In order to avoid the use of the expensive main air plant some of the contractors used small independent portable compressors in the tunnel, driven by gasoline or electricity, and mounted on cars travelling along with the other equipment. These compressors were used both for the low and high-pressure grouting.

On the work in the northern portion of the City Tunnel, low-pressure grouting was carried on with three rigs, each consisting of the following equipment:—One 30 h.p. electric motor; one Ingersoll-Rand 2-stage, belt-driven air compressor, capable of delivering 170 cub. ft. of free air per minute at 100 lb. pressure and 130 cub. ft. at 350 lb.; one geared pump, with a capacity of 50 gallons per minute, driven by a 7½ h.p. electric motor; two grout tanks, two water tanks, a platform car for making connections to the grout pipes, and a platform mounted on two flat cars for the cement and sand. For high-pressure grouting the same rig was used, the compressor being adjusted to deliver air at 300 lb. per square inch.

Grouting by Air and Water Pump.—In the Hudson

Tunnel, where it was necessary to use grouting pressures of 700 lb. per square inch, a combination of air and water-pressure pump was devised. A Canniff tank was partly filled with grout, which was placed under a pressure of about 300 lb. by a Westinghouse booster connected, as usual with the tank. Water was then pumped into the tank through another connection by a high-pressure Cameron pump, reducing the volume of air above the grout so as to raise the pressure to 700 lb. per square inch, if desired. The discharge valve of the tank was then opened and the pump was kept going in order to maintain the pressure while the grout flowed slowly into the space back of the lining. This arrangement worked very successfully. The advantage of a pump with a steady flow lies in the fact that there is no after-blast of air forced through the grout.

Paddle Mixing Machines.—In a few cases, paddle mixing machines which mix the grout mechanically instead of by air, were used. The results obtained by these machines are good when they are new, but the moving parts and the stuffing boxes soon give trouble on account of wear. The bad feature of both the air-stirring grout tanks and the paddle mixing machines is the blast of air which follows the discharge of grout. As already noted, it is very important to control the discharge of air in grouting in order to secure good results.

Grouting Pads.—The specifications called for the use of grouting pads for forcing grout into any porous concrete in the lining. These pads consisted of a steel casting measuring about 1 ft. by 2 ft. 3 in., containing a rubber gasket, and mounted at the end of a 5-in. extra heavy-wrought iron pipe. In using the grout pad it was jacked against the porous spot in the lining by screw-jacks at the other end of the column, and the grout was then forced into the pad to impregnate the concrete. These pads were not successful as they were clumsy to handle, the area covered by the pad was too small for effective work, and the gaskets would blow out. After a few attempts their use was given up.

Only a few porous spots occurred in the concrete lining through which grout leaked during low-pressure grouting, and it was found that the most effective method of treatment was to wedge a board faced with oakum against the porous spot. The flow of grout soon stopped and the opening closed up.

SPECIAL GROUTING IN PRESSURE TUNNELS.

Grouting Wet Stretch, Rondout Tunnel.—This pressure tunnel, 4.4 miles long, was constructed from eight shafts, varying in depth from 370 ft. to 708 ft. The shafts and tunnel penetrated eight distinct formations, including shales, limestones and quartz conglomerate. Several stretches of faulted zones and crushed rock were encountered in the excavation. Some strata were dry; others were very porous and water-bearing.

As already described the tunnel north of Shaft 4 was driven on a 15 per cent. grade through a badly faulted and folded stretch in High Falls shale and Binnewater sandstone. The rock was porous and water-bearing, the inflow in a stretch of 350 ft. being approximately 2,000 gallons per minute at the time the tunnel was driven. The flow gradually diminished until it was somewhat less than 1,000 gallons per minute at the time the lining was placed. The tunnel at this location is about 450 ft. below the surface of the ground. An attempt to shut off the inflowing water by grouting at the time of driving has been described.

It would have been difficult to take care of the water by means of drip-pans during the placing of the lining, as it poured into the tunnel over large areas. The plan adopted to protect the concrete during placing was to enlarge the excavation through the wet stretch in order to permit the erection of a light steel shell (see Fig. 4), inside of which a concrete lining, 24 in. thick, was placed. The shell was 175 ft. long, and consisted of circular ribs of 7-in., I-beams set 5 ft. centre to centre along the tunnel, with ¼-in. plates bolted to the outside of the ribs. The space between the shell and the rock, which averaged about 20 in., was packed solid with broken stone and subsequently grouted.

Most of the water entering the tunnel in this stretch was interrupted by 6-in. lateral pipes draining into an 8-in., spiral-riveted drain laid longitudinally along the bottom of the tunnel. This drain discharged through an 8-in. valve into a sump at the foot of the wet stretch. Water was also collected through holes drilled into the rock seams to depths of from 3 ft. to 4 ft., into which 2-in. deep-seated pipes were set, which extended through the dry packing and the steel shell and drained into the tunnel. Pipes were also placed through holes in the shell to reach the dry-packed space for the purpose of grouting the packing behind the shell.

The concrete invert, which averaged about 3 ft. in thickness, was laid first on the floor of the tunnel over the 8-in. drain. The invert was placed in short stretches, 25 ft. and 40 ft. in length, with tight wooden bulkheads and forms. Any leakage in the bottom was taken care of by pans and broken stone drains covered with cement bags. The placing of the invert was very difficult on account of the heavy flow of water from the bottom and sides of the tunnel. After the invert was placed the steel shell was erected and the space between the shell and the rock was dry-packed at the same time. The lining was then placed inside the shell without any trouble.

Preliminary to grouting this stretch, tight brick cut-off walls were built between the shell and the roof at each end of the shell. When grouting was started the valve at the lower end of the 8-in. drain was closed and the valves of all the pipes leading into the dry packing were also closed. The dry-packed space was quickly filled, forming a pond of still water, into which neat cement grout was injected. Experiments previously made showed that the materials in sand grout might separate if forced in under water. The deep-seated pipes and a few pipes at the top of the shell were left open to prevent accumulation of pressure.

Grouting of the dry packing was begun at the lower end of the shell. A battery of four Canniff grout tanks was used, the grouting of both sides of the tunnel being carried on simultaneously. The space behind the shell filled gradually, the level of the grout being indicated by opening pipes at various levels. A few of the deep-seated pipes flowed grout during this operation. They were closed, but were re-opened about 24 hours later and rodded out, after which they again flowed clear water, but in a somewhat reduced volume. In the whole section the inward leakage was reduced from 850 to 540 gallons per minute after grouting the dry packing, showing that the seams had been partly closed. The grout was injected into the dry packed space, generally under low pressure, without causing undue agitation. The final grouting was done under a pressure of 90 lb. per square inch at the top of the shell. A total of 7,700 batches of neat grout (1.2 cub. ft. per batch) was forced into the dry packing, requiring 10 shifts.

After the grout had set a few days the deep-seated pipes through which several hundred gallons of water per minute issued into this tunnel were grouted, beginning at the bottom of the shell and working up. During this process varying consistencies of grout were used, the thinnest being ¼ bag of cement (about 24 lb.) to 30 gallons of water. After applying air pressure to clean out a rock seam the thinnest grout was used first. If a considerable quantity, 20 to 30 batches, went into the rock under comparatively low pressure (100 lb. or less), the grout was thickened, 48 lb. to 30 gallons of water being used. If a considerable quantity of this grout was injected the mix was again thickened, this process being continued until the tank pressure necessary for injection began to rise, when the mix was thinned slightly and grouting continued until the pipe refused under 300 lb. pressure. The pipe was then drained out and plugged with thick neat cement grout under 300 lb. pressure. The maximum number of batches injected into a pipe was 533.

The grouting reduced the leakage on the incline from 850 gallons to 3 gallons per minute, and although the level of the water in the rock reservoir, as indicated by gauge readings, rose gradually after the completion of the grouting until the original ground-water level had been restored, there was no marked increase in the quantity of water entering the tunnel. Test holes drilled through the concrete lining and shell and into the rock showed that the rock surrounding the tunnel was impregnated with grout to a considerable depth. The success of the grouting at this location was due to the use of the deep-seated pipes, and, more particularly, to the method adopted whereby the dry-packed section outside of the lining and shell permitted the grout to come in direct contact with the surface of the porous rock.

Grouting Large Mud Seams, Rondout Tunnel.—In driving the tunnel through the Helderberg limestone south of Shaft 3, Rondout Tunnel, a crushed and faulted zone containing a number of large solution cavities filled with residual clay was encountered. The two widest seams were vertical and cut diagonally across the tunnel at an angle of about 45 deg. to the tunnel axis. These two seams were 16 ft. and 25 ft. wide on one side of the tunnel, but much narrower on the other side. They were filled with clay and disintegrated rock and, while excavating the tunnel, were lagged with steel channels supported by steel beams and timbering. The lining at the seams was strengthened by embedding steel shells, ½ in. thick and 41 ft. and 59 ft. in length, in the concrete at each seam. In addition to reinforcing the lining, these shells also serve to prevent outward leakage from the tunnel.

In this stretch, a horizontal seam about 3 ft. thick also was encountered, the bottom of the seam lying about 4 ft. above the finished waterway. The mud layer was removed and the space above the waterway, about 7 ft. high, was subsequently filled with concrete. Above the horizontal mud seam was an opening in which were three rows of narrow vertical pockets, extending diagonally across the tunnel. These pockets were from 2 ft. to 6 ft. wide and ran from a few feet to 30 ft. above the roof of the tunnel. Concrete was placed up to the top of the general roof excavation and the space above, including the narrow pockets, was filled with grout through pipes set in the concrete. A total of approximately 9,000 batches of 1 : 1 grout was placed in this stretch, requiring 13 days of three shifts each.

Rupture of Lining and Repair Work, Rondout Tunnel.—On the completion of the tunnel and shafts, they were filled with water for a hydrostatic test. Excessive leakage developed in the Rondout Tunnel (Fig. 5), and after unwatering it, on examination showed that the lining was cracked in three stretches aggregating in length about 700 ft. The upper half of the tunnel section appeared to be lifted from the lower portion, water issuing in large quantities through the joint at the springing line and through other diagonal cracks in the lining.

To determine whether the lining had ruptured on account of unfilled places over the top of the arch, a test hole was cut, and several holes were drilled through the concrete to the rock in the roof. The space was found to be completely filled with grout, which was intact and in close contact with the rock. The rupture of the lining was due to the movement of the rock outside of the tunnel resulting from the application of hydrostatic pressure.

The tunnel was reinforced through the ruptured stretches by steel lining built up of rings of circular segments of 15-in. 55-lb. channels. A 2-in. annular space was left between the steel and the existing concrete lining. Preparatory to placing the steel, the cracks through which water issued were caulked with lead, thereby forcing the water into pipes, drilled through the lining into the rock seams.

The space between the steel shell and the old concrete lining was first grouted. Every twelfth ring of steel had eight holes placed equally around the circumference, tapped and plugged for grouting. A 1 : 1 grout was used under a pressure of 30 lb. per square inch. After this grout had set for one week, the deep-seated pipes leading to the wet seams were grouted. Very thin grout, ¼ bag to 35 gallons of water, was forced in until the hole refused at 300 lb. pressure. The thin grout was then drained out of the pipe, which was sealed with a thick batch. A total of 743 bags of cement was injected through 89 pipes. The leakage in this section before repairs were started amounted to about 400 gallons per minute. After all the concrete was placed and all the grouting was finally completed, it was reduced to 2 gallons per minute.

To protect the steel shell against rusting, and to provide a smooth waterway, a concrete lining, averaging 6 in. in thickness, was placed inside the steel shell. To fill the space above the arch, a grout and a vent pipe were placed in each pocket formed by the projecting flanges of the channels. A thick 1 : 1 mixture was used for the grouting, the grout being placed by a Douglas hand pump. After this grout had set, and the surplus water was allowed to drain off, a second grouting was done with neat cement, completely filling the space between the lining and the steel shell.

Wallkill Pressure Tunnel.—This tunnel crosses the Wallkill Valley for a distance of 4½ miles, at an average depth below the ground surface of 350 ft. to 450 ft. The rock penetrated was the Hudson River shale formation, and was generally sound and dry. For the greater length, the rock was a rather fine-grained shale with some beds of hard sandstone; for about a mile at the south end of the tunnel, it was mainly sandstone in very heavy beds. The dip of the rock for the greater length of the tunnel averaged about 45 deg., striking at an angle of about 30 deg. with the tunnel line. At the north end, the bedding was vertical and at right angles with the tunnel axis; while for a considerable distance at the south end the beds were horizontal, causing high breakage above the roof.

The inward leakage when the tunnel was driven amounted to approximately 500 gallons per minute in the tunnel and 180 gallons per minute from the shafts. Although no great concentrated flows of water were met, certain stretches were water-bearing over large areas and the rock was extensively covered by pans to catch the water. Eight stretches of 1,000 ft. in length yielded an inward flow of more than 20 gallons per minute before grouting. The maximum inward leakage of ground-water was 90 gallons per minute for 1,000 ft. of tunnel.

In many places the water entered in fine sheets under head between the layers of shale. It was found to be practically impossible to force any quantity of grout into this rock on account of the fine openings between the thin layers. The wet areas were covered by drip-pans and grouted under high pressure with neat cement grout by filling the pans solidly full, sealing the fine openings, and effectively cutting off the water.

An interesting movement of the flow of water in the rock during grouting occurred between Shafts 1 and 2. The total leakage in this stretch just prior to starting grouting was 125 gallons per minute. There was little diminution in the leakage after the low-pressure grouting, and it was not until the high-pressure grouting plant had travelled a distance of about 3,000 ft. south from Shaft 1 to within about 2,000 ft. of Shaft 2, that any marked change in the inflow occurred. In two days of grouting, the leakage in this stretch dropped to 70 gallons per minute.

Evidently, the water in a length of 3,000 ft. of tunnel, south of Shaft 1, was forced ahead during the high-pressure grouting, finding an outlet through grout pipes in the arch south of the grouting machine. There was a soft seam or plane of movement above the roof of the tunnel in this stretch, running nearly parallel with the tunnel, and apparently the water was forced through this seam during the grouting. On the completion of the grouting, the leakage in this stretch was reduced to 22 gallons per minute.

Moodna Pressure Tunnel.—This tunnel is 4·8 miles long, and from 300 ft. to 400 ft. below the surface of the ground, the maximum depth below the hydraulic gradient being about 600 ft. The tunnel penetrated Hudson River shale for about 60 per cent. of the distance and granitic gneiss for the remainder of the length. The shale was generally soft, although there were many layers of hard sandstone; the rock was much disturbed and without uniformity of attitude. The gneiss was hard and sound, but intersected in every direction by joint planes as a result of the disturbance due to a great overthrust fault which extends for many miles along the contact between the gneiss and the Hudson River shale formations.

The inward leakage for the entire tunnel, including the shafts, was 640 gallons per minute, when the excavation was completed. The shale was better than the gneiss, but there were no large concentrated flows anywhere. Very few holes were drilled for deep-seated pipes, as practically no well defined water-bearing seams were encountered. In the shale, a drip-pan was placed about every 7 ft. or 8 ft. of tunnel.

The rock throughout was generally firm, and only 3 per cent. of the length of the tunnel required roof support. Although several zones of extensive rock movement were penetrated, there were no large openings or excessive inflows at these places, and special treatment was required in only one case, where badly crushed and unstable ground was encountered beneath the surface valley known as Pagenstecher Gorge.

In this stretch, a flow of about 100 gallons per minute was struck when the heading was first excavated. The water issued from a crevice 6 in. wide, marking a plane of movement and solution in the gneiss. The adjacent rock was crushed and disintegrated, and required a steel roof support for a distance of 55 ft. along the tunnel. Following the first rush of water from the crevice, the

leakage gradually diminished, as the underground storage was exhausted, until it was less than 10 gallons per minute.

The rock broke very high and wide at this place, and, in making arrangements for grouting, long grout pipes were set to reach the top and sides of the cavity. The longest pipe extended 20 ft. above the roof of the tunnel. The dry packing between the steel support and the rock was first grouted, the operation being continued until the water-bearing crevice was filled. After the grout had settled and set, the long pipes were opened up and drained, and any remaining spaces were filled with grout under a pressure of 300 lb. per square inch.

Repair Work in Moodna Pressure Tunnel.—The Moodna Tunnel connects at the south end with the tunnel under the Hudson River by a shaft on the west bank. Although the rock in Moodna Tunnel adjacent to the West Shaft was dense and solid when excavated, the application of hydrostatic pressure, when the tunnel was tested, caused a movement along the joint planes, with rupture of the concrete lining both in the West Shaft and in a stretch of Moodna Tunnel adjacent to the shaft. As the joint planes in the rock were closed and tight before the test pressure was applied, it would have been impossible to prevent the yielding of the rock by grouting, no matter how thorough and extensive, prior to the hydrostatic test. The cracks in the lining through which considerable water issued were subsequently caulked, and the rock was grouted. Later, it was decided, on account of the geological conditions which the test had revealed, to abandon 900 ft. of the tunnel adjacent to the West Shaft, and a new tunnel was driven 400 ft. below the old one. No further trouble was experienced at this location.

Hudson Pressure Tunnel.—This tunnel, placed 1,100 ft. below the river surface, penetrated sound Storm King granite throughout its entire length of 3,100 ft. Numerous black diabase dikes were found along the joint planes. The granite has shared with the entire Highland area in folding and faulting movements which broke up the rock into blocks separated by joint planes. In excavating the tunnel, some water from the river entered through this system of joints.

The grouting of a wet seam near the East Shaft in driving the tunnel has been described. Contrary to expectations, the leakage of water into the tunnel was not excessive, and was taken care of in the usual manner by the use of drip-pans and deep-seated pipes. The total inward leakage after the completion of the concrete lining and prior to grouting was 160 gallons per minute, the greater part occurring near the western portion of the tunnel.

As already described, some trouble was experienced in this tunnel on account of the cracking of the concrete lining in the side-walls, when the high grouting pressures, running up to 600 lb. per square inch, were applied. After the cracks were cut out, the lining was replaced and again grouted under lower pressure, and no further trouble developed. As noted, a soft deposit was found between one of the drip-pans and the rock at one of the cracks which had been cut out, which probably prevented the filling of the space with grout. Several unusually large drip-pans were used in the wet stretches, and this may have been a factor in the cracking of the lining, as the very high grouting pressures were applied over large areas where the lining was not very thick.

No attempt was made to shut off all inflowing water in this tunnel by grouting, and the pipes which flowed water were fitted with bronze check-valves. These valves prevent the accumulation of rock-water pressure on the lining, when the tunnel is empty, by permitting the water to flow freely into the tunnel, and also, by closing tightly, prevent the loss of water from the tunnel when in service.

The high pressures necessary for grouting this tunnel were obtained by the use of a high-pressure pump which discharged the grout in the grout tank by pumping water into the tank. This tunnel proved to be remarkably tight when tested, and the loss of water when in service is very little.

Repairs in Breakneck Pressure Tunnel.—This tunnel, 780 ft. long extends from the East Shaft of the Hudson Tunnel to an uptake shaft on the north slope of Breakneck Mountain. It penetrated the same granite formation as the Hudson Tunnel, and the rock was sound and dry. In the portion adjacent to the East Shaft, where the rock cover is comparatively shallow, cracks developed in the tunnel lining, as well as in the upper portion of the East Shaft, when a hydrostatic test was made, due to yielding of the rock along the joint planes. The lining was repaired by drilling holes about 10 ft. deep through the concrete and into the rock, and injecting thin grout under pressure. Most of the holes took little grout, but there were a few into which a considerable quantity was forced.

The grout was mixed in the proportions of 25 lb. of cement to 20 gallons of water, and, in some cases, even thinner. Water was used for washing out the seams and frequently permitted further grouting after a hole appeared to be plugged. One hole, in the vicinity of a fractured zone in the rock, took 5,217 batches of grout containing 328 barrels of cement. This hole was almost plugged several times, but was opened by flushing with water.

During grouting, the grout did not appear in any of the other holes in the vicinity of the pipe grouted, but was evidently forced some distance from the tunnel. Only four holes took more than 25 barrels of cement. A total of 556 barrels of cement was used in grouting the tunnel and 39 barrels in the East Shaft. The repairs were successful in reducing the outward leakage to a small quantity.

City Pressure Tunnel.—The City Tunnel forms the great distribution main within the city limits. It is 18 miles long, and is located beneath the streets and parks of the Boroughs of The Bronx and Manhattan, extending from the Hill View Reservoir, just north of the city line, to two terminal shafts in Brooklyn. The tunnel was constructed from 24 shafts, varying in depth from 218 ft. to 757 ft.

The tunnel was placed everywhere at a depth of not less than 150 ft. below the surface of sound rock. The rock is at or near the surface over the greater part of the line, and more than half of the length of the tunnel is little more than 200 ft. below the surface of the ground. In order to secure the required depth of sound rock over the tunnel under the Harlem and East Rivers, the tunnel was placed 330 ft. and 700 ft., respectively, below the surface.

The formations penetrated in the City Tunnel, namely, Yonkers and Fordham gneiss, Inwood limestone, Manhattan schist, and Ravenswood diorite, are generally sound and durable rocks, but were found in many places to be disturbed by folding and faulting, with extensive crushed zones. Intrusions of pegmatite were frequently met. The underground waters circulating through channels formed by mechanical fracture and solution have caused chemical changes in many stretches, with resulting alteration and weakening of the mineral constituents of the rock. For the greater part of its length, the tunnel was driven approximately parallel with the strike of the rock, the dip being generally nearly vertical.

With the exception of two or three stretches, where heavy flows of water were encountered, the rock throughout the length of the tunnel was generally dry, and seeping water was taken care of by the methods used in the other tunnels. On account of the location of the City Tunnel, in the heart of the city, unusual precautions were taken in handling the water and grouting, in order to reduce, as far as practicable, the loss of water out of the tunnel, as it was evident that excessive leakage would be exceedingly troublesome and might result in the settlement of buildings.

Grouting under Harlem River, City Tunnel.—The tunnel under the Harlem River Valley penetrated Inwood limestone, a white crystalline marble, solid and dry for the greater part, but, for a distance of about 200 ft., a blocky stretch with water-bearing seams was encountered, yielding a flow of about 200 gallons per minute. A number of large crevices, several inches wide, extended above the roof and from the sides of the tunnel. Grout pipes, some 20 ft. long, were inserted in these crevices.

All the leaks in the sides and roof of the tunnel were panned, while, in the bottom, where considerable water issued, a broken stone drain covered by pans was laid below the invert concrete. The inflowing water was drained by a longitudinal pipe on the bottom. During the placing of the invert concrete, the water was kept below the top of the stone drain by pumping through the longitudinal pipe and pumping was continued until the concrete had set.

The grouting in those portions of the tunnel adjacent to the wet stretch was completed before any leakage in that stretch was cut off. Grout was first forced into the bottom drains and pans, the upper pipes being left open to relieve the water pressure. Connections were made successively to the pipes at higher levels, until the crevices in the roof were filled. The final grouting was done under a pressure of 300 lb. per square inch, using thick cement grout. The grouting was very successful, the inward leakage in this stretch being reduced to 3 gallons per minute.

Grouting the Wet Stretch near Shaft 23, City Tunnel.—The wettest stretch in the City Tunnel was encountered near Shaft 23, where, in a crushed zone in granodiorite, a flow of 600 gallons per minute, issuing from one seam, was struck when the excavation was first made. This flow had diminished to 325 gallons per minute, at the time the concrete lining was placed. On account of the large flow, it was decided to use a light steel shell to protect the concrete, instead of the customary drip-pans.

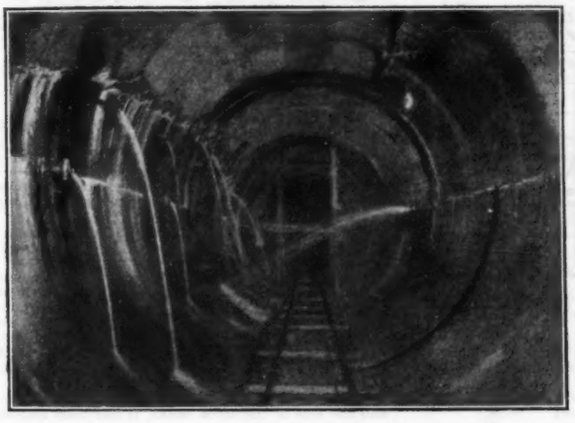


FIG. 5. BROKEN TUNNEL LINING, RONDOUT PRESSURE TUNNEL. CRACKS DUE TO YIELDING OF ROCK. LEAKAGE REDUCED FROM 400 TO 2 GALS. PER MIN. BY GROUTING.

FIG. 6. STEEL INTERLINING THROUGH DECOMPOSED ROCK, CITY TUNNEL, UNDER 106TH STREET. SPACE BACK OF LINING CONSOLIDATED BY GROUTING.

The construction was similar to that in the Rondout Tunnel and consisted of ribs built up of 4 in. by 3 in. by ⅜ in. angles spaced 5 ft. centre to centre, on which plates ½-in. thick were placed. Each rib was made in four segments, the bottom being embedded in the invert concrete. Where the rock showed any leakage, the space between the steel shell and the rock was filled with dry packing, elsewhere the steel plates were omitted, and the concrete lining was placed directly against the rock. Dry packing was placed over about 60 per cent. of the area in the 90 ft. of tunnel in which this special construction was used (Fig. 6).

The water in the wet stretch was drained by a 10-in. tile pipe, laid with open joints on the floor of the tunnel and surrounded by broken stone. Above the top of the broken stone, corrugated sheet iron was placed, on which the invert concrete was laid. The 10-in. tile drain had a slope of 6 in. in 100 ft. and discharged the water into a sump at the end of the wet stretch. From the sump, the water was pumped into an 8-in. discharge line in the tunnel by a motor-driven centrifugal pump.

After all the other grouting in the tunnel between Shafts 23 and 24 had been completed, that in the wet stretch was begun by first connnecting to the pipes in the bottom drain and then successively to the pipes at the higher levels, raising the grout up to a maximum of 150 lb. per square inch. By this means, most of the grout was placed against a back pressure of 50 lb. per square inch or less, the gauge registering finally 90 lb. per square inch when the grouting plugged it.

In order to prevent the accumulation of ground-water pressure, all the pipes except those in the invert were left open, or were opened up after the grout had set. After the deep-seated pipes were grouted under a pressure of 300 lb. per square inch, all the pipes were opened and connected to for high-pressure grouting. A total of 217 batches of neat cement grout, consisting of 1 bag of cement (95 lb.) and 6 gallons of water, was used for the high-pressure grouting in this stretch. Very successful results were obtained in cutting down the inward leakage which was reduced by grouting to 6 gallons per minute for the entire stretch of 3,600 ft. of tunnel

between Shafts 23 and 24. Inspection of the tunnel after a hydrostatic test under the operating head, showed no cracking or inward leakage in this stretch.

Repairs in City Tunnel between Shafts 18 *and* 19.—The portion of the City Tunnel underneath Broadway, in the vicinity of 23rd Street, was excavated through fairly sound Manhattan schist, with no inward leakage. When the tunnel was subjected to a hydrostatic test, some water appeared at the surface in Madison Square-park and in some of the cellars near-by. Although the outward leakage was not excessive, it was decided to make an effort to cut down the quantity as much as practicable. On unwatering the tunnel, it was found that, due to movement of the surrounding rock, the construction joints of the tunnel lining had opened up and, in addition, some of the lining was cracked. Four stretches of tunnel aggregating 1,350 ft. in length were affected.

The method of repair adopted was to consolidate the rock surrounding the tunnel by grouting and, in addition, to line with sheet copper two stretches aggregating about 1,200 ft. of tunnel (see Fig. 5). A large number of holes, 2 in. in diameter, were drilled through the concrete lining and into the rock, the size of the tunnel limiting the maximum depth of the holes to 10 ft. In the 1,350 ft. of tunnel grouted, approximately 10,000 lineal ft. of holes were drilled. Pieces of 1¼-in. pipe, 15 in. long, were fitted into these holes.

Before grouting, grooves were cut in the joints and cracks through which water entered the tunnel, and these joints were caulked with lead wire. The customary grouting equipment was used for this work, air at 90 lb. being furnished by a compressor at the top of the shaft. Higher pressures were obtained by Westinghouse "boosters."

After connecting to a hole, grouting was continued, until the hole refused grout under 300 lb. pressure. Any leaks that developed during the grouting were located, and, after the grout has set, additional holes were drilled at the place of leakage. The process of drilling and grouting a section was continued until test holes, drilled 10 ft. deep, did not leak or take grout. The stretches in which the lining was cracked were grouted three times, a portion of one being grouted five times.

The mix ordinarily used consisted of batches containing 25 lb. of cement to 20 gallons of water. If a hole into which 75 batches of this consistency had been injected, continued to take grout freely, the mix was thickened to 25 lb. of cement and 5 gallons of water; but if the hole showed a tendency to plug, the thin mix was again used. A total of 6,000 bags of cement were used in grouting the 1,350 ft. of tunnel.

When the grouting was started, the inward leakage amounted to 30 gallons per minute, practically all of which was cut off by grouting. The ground-water head against the lining during grouting, as indicated by gauges, was 78 lb. per square inch. After the tunnel was again placed in service, there was practically no leakage at the surface of the ground.

(To be continued.)

OPERATING A BY-PRODUCT PRODUCER GAS PLANT.

*Notes on Operating a By-Product Producer Gas Plant for Power and Heating.**

By W. H. PATCHELL, Member.

(Concluded from page 531.)

OPERATING RESULTS.

Fuel.—Owing to war conditions the supply of coal was very uncertain and, in consequence, various kinds were used. In January, 1918, some 795 tons of coal of nine different sorts were gasified. By December, 1918, deliveries had improved and were only of five different sorts. It will be readily understood that such variations do not improve working conditions.

The ashes withdrawn from the producers during 1918 averaged a carbon content of 11·8 per cent., which represents 3·23 per cent. of the therms in the coal.

The results given in this paper were obtained without special arrangements and under normal conditions, and can be taken as typical commercial results. No effort has been made to obtain special test figures which are not realised under ordinary working conditions.

Steam required for Gas Plant.—The amount of steam required is considerable, mainly for use in the producers and for evaporating the sulphate liquor. In addition to these uses there are tar troughs to be heated, tar tanks to be kept at such a temperature that the tar for burning is quite fluid, and various incidentals about the plant. In order to obtain some accurate figures of the steam consumption one Lancashire boiler was isolated and used for steam supply for the gas plant only, and a test extending over one week was carried out.

Coal gasified	136 tons 10 cwt.
Water evaporated	447,600 lb.
Coal used in boiler	24 tons 7 cwt.
Tar used equal to 6 tons coal	6 tons 0 cwt.
Coal equivalent used on boiler	30 tons 7 cwt.

Equal to 22·25 per cent. of the coal gasified.

Amount of sulphate salts made: 6·256 tons, or 102·6 lb. per ton of coal gasified.

A second test under similar conditions showed :—

Coal gasified	145 tons 15 cwt.
Coal equivalent used on boiler	33 tons 18 cwt.

Equal to 23·25 per cent. of the coal gasified.

These figures are rather high, as the Lancashire boiler available for the test is capable of evaporating three times the amount of water required, and was not working therefore at an economical rate. As, however, the above tests were taken in May and June, and the heat losses would be slightly greater during the cold months of the year, the costs given later allow for coal for steam raising at 25 per cent. of the coal gasified.

A charge of approximately 25 tons of coal for steam required for the producer and gas plant only, for every 100 tons of coal gasified, is a heavy item in working costs and one that must always seriously affect the use of by-product producer plants.

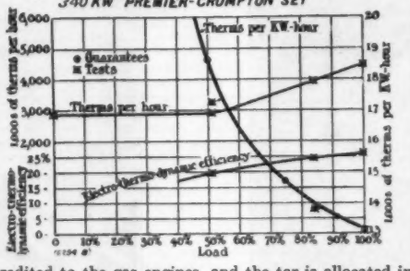
Messrs. Hoffmann recognised that their conditions would be favourable for adopting this type of plant, coupled with an installation of exhaust boilers. By using these boilers and burning tar 75 per cent. of the 25 per cent. of the coal required for the gas plant is cut out, and the actual coal required for gas plant steam is reduced to 6·25 per cent. of the coal gasified.

Coal Consumption and Thermal Efficiency.—As already pointed out the coal supply varied very considerably, consequently the results are not so good as they would have been if one kind of coal only had been used. It is a well-recognised fact that a mixture of coals in a producer leads to difficulties unless a suitable choice can be made. In the plant under review it was a case of "Hobson's Choice."

Figures for six months' operation of one 30-ton gas plant supplying gas for two engines and furnaces may be analysed to show how the efficiency would appear if all the gas were used for power. The result is summarised in Table II opposite.

During this period the total coal gasified was 3,255 tons, giving an average load of about 75 per cent. during operating hours of the plant. Of the total amount of gas made 42·7 per cent. was used for the engines and 57·3 per cent. for the furnaces. For this purpose the whole of the steam raised by the exhaust boilers is credited to the gas engines, and the tar is allocated in proportion to the gas used by the engines and the furnaces respectively.

Fig 3. HEAT CONSUMPTION CURVES OF 500 B H P 340 KW "PREMIER-CROMPTON" SET



The figures used for converting the work done by the exhaust boilers and by tar to a common coal equivalent are :—

Exhaust boilers ...	1 b.h.p.-hour = 2 lb. steam.
Lancashire boilers...	1 lb. coal = 6
Lancashire boilers...	1 lb. tar = 7½

Based on these equivalents the amounts of coal saved during the six months by the use of the exhaust boiler and by burning the tar are :—

	Tons.
By exhaust boiler	379·75
By-tar burning	114·70
Total	494·45

During the period the two engines generated 1,834,375 units, giving an engine load factor of 73·6 per cent. on running hours.

The above table shows the actual coal gasified in pounds per kilowatt-hour; also what it would have been on the 25 per cent. basis if all the steam for use on the gas plant were made by coal-fired boilers; finally, the equivalent coal for the amount of steam actually made by the exhaust boilers and by tar burning, and its effect on the coal consumption per kilowatt-hour. The net amount works out at 1·51 lb. per kilowatt-hour and is the figure used in the working costs given later.

The average calorific value of the fuel over this period was 11,333 therms per pound, giving an overall thermal efficiency of :

$$\frac{\text{Therms per kw.-hour at switchboard}}{\text{Cal. value} \times \text{net coal used per kw.-hour}} = \frac{3{,}412{\cdot}5}{11{,}333 \times 1{\cdot}51} = 19{\cdot}9 \text{ per cent.}$$

As will be seen from the table more steam is raised by the exhaust boilers than is required to make gas for the engines. In other words exhaust boilers in connection with gas engines at a gas works would provide all the steam required for the producers, working under by-product recovery conditions, necessary to provide the gas for the engines when working on a good load factor.

Gas Consumption and Quality.—Owing to the large quantity of gas made, 130,000 cub. ft. to 140,000 cub. ft. per ton of coal gasified, it was found that the cost of metering apparatus to record the whole of the gas made was too high to warrant its installation.

A rotary meter capable of measuring the amount of gas taken by two "Premier" engines was purchased and provision made for fixing it in various parts of the plant, so that tests could be made in the different engine-rooms. The amount of gas used on the Premier engines has been calculated from the results so obtained.

The test for the correctness of the meter at the makers' works was as follows :—

At 80,000 cub. ft. to 20,000 cub. ft. per hour ... ... Correct.]
At 10,000 cub. ft. to 8,000 cub. ft. per hour ... ... 2 per cent. slow.

Fig. 3 gives curves of the heat consumption guaranteed, the results of tests of the same, and the thermal efficiency of the Premier-Crompton sets.

The working costs given later were calculated from the guaranteed curve plus an additional allowance for preliminary runs and starting up; consequently the figures are on the safe side.

To obtain a record of the calorific value and of the composition of the gas made, two methods were adopted. A recording calorimeter of the "Sarco" type was installed. This apparatus shows the calorific value of the gas and records continuously any variations that may occur therein. It is a very useful instrument but requires checking from time to time.

For more detailed tests and analysis an aspirator is used which draws off gas over a long period. The sample thus obtained is analysed in a Hempel's absorption pipette with suitable reagents.

Table III gives the results over a period of three months, from which it will be seen that the variations are very slight considering the different qualities of coal used.

Tests of the engines have been made, representative figures of which are given in Table IV.

The efficiency of the Crompton dynamos on a "Hopkinson" test was found to be :—

	Per Cent.
Full load...	92·0
Three-quarter load	91·0
Half-load	90·5

As regards operating, the engines have run with the regularity and the freedom from trouble of a good steam engine.

The total operating hours for 1918 were :—

Engine.	Hours' Run.	Compulsory Stoppages.
No. 9	6,291	52½ hours, of which 43 hours was due to exhaust boiler.
No. 10	6,588	32½ hours.

Those who are interested in the compression-pressure question may note that the pressure in these engines is 120 lb. per square in.

Exhaust Boilers.—Tests of these have been made with and without the water heaters. Specimen tests are given in Table V.

Sulphate of Ammonia Recovery.—The amount of sulphate recovered depends on the amount of nitrogen in the coal, this is usually in the neighbourhood of 1·3 per cent. from which theoretically 136·5 lb. of sulphate should be made; actually, as will be seen from Table VI, some 90 lb. is recovered—an efficiency of about 65 per cent. The sulphate is of a good light grey colour, and averages over 25 per cent. NH_3.

Owing to the varying qualities and quantities of coal, and the size of the stock tanks, it has been impossible to obtain a straight test.

A recovery of 65 per cent. of the nitrogen in the coal appears, at first sight, rather low, but the difficulty in sampling must be remembered and a sample taken by the men who unload the trucks cannot altogether be relied on as showing the average of the bulk.

A more critical figure for the ammonia absorber efficiency is given in Table VII, which shows the amount of ammonia per cubic metre of gas when entering and when leaving the absorber, the actual ammonia not recovered being equal to only 4·25 per cent.

TABLE VII.—*Recovery of Ammonia in Absorber.*

—	Grammes NH_3 per Cubic Metre in the Gas.		
	Entering Absorber.	Leaving Absorber.	Efficiency, per Cent.
Average of 14 tests.. ..	2·73	0·116	95·75

Use of Tar.—The amount of tar produced in the process varies with the class of coal used; 5 per cent. to 7 per cent. of the weight of the coal is a normal figure for dry tar. The tar as made contains anything up to 40 per cent. of water.

There is a good market for gas works tar, and no difficulty generally occurs in disposing of it. Producer tar, however, is of a different quality and is not usually acceptable to distillers of gas tar. Where the quantity of tar to be handled is sufficiently great to pay for distillation, it may be economically dealt with in this way; but it must be remembered that tar distillation requires special care and attention, particularly when it may be emulsified with water, and if the quantities to be handled are not sufficient to pay for such care and attention the result will be disappointing.

Full consideration of the matter led to the use of the tar recovered, which amounts to about 150 lb. per ton of coal gasified, in the boiler furnaces. Jets of the Kermode type were fitted, through which the tar is blown by steam over the grates. A compromise had to be arrived at as it was not possible to allocate any one furnace for burning tar only, and the arrangements had to be such that coal and tar could be burned at the same time. At times of light load it has been found

* Paper read before the Institution of Electrical Engineers on Thursday, March 11, 1920.

TABLE II.—POWER-PLANT COAL CONSUMPTION.

Coal Gasified in Producers.		Coal if 25 per Cent. is Required to Provide Steam.	Coal Gasified plus Coal for Steam-Making.		Amount of Coal Saved.		Surplus Steam used for Manufacturing Purposes.	Actual Coal to be Debited to Power Plant.		Load Factor Gas Engines.	Overall Electro-Thermal Efficiency.
Total.	Per Kw.-Hr.		Total.	Per Kw.-Hr.	By Exhaust. Boilers.	By Tar Burnt.		Total.	Per Kw.-Hr.		
tons.	lb.	tons.	tons.	lb.	tons. 379·75	tons. 114·7	tons.	tons.	lb.	per cent.	per cent.
1,390	1·7	347·5	1,737·5	2·12	494·45 tons		146·95	1,243·05	1·51	73·6	19·9

TABLE III.—AVERAGE ANALYSIS OF PRODUCER GAS MADE.

Date, 1918.	Number of Tests.	Average Period Covered by each Sample.	CO_2	O.	CO.	CH_4.	H.	N.	Total Combustible.	Calorific Value per Cub.Ft.
		hours.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	therms.
Three months ..	42	12·6	15·8	0·15	10·68	2·59	26·6	44·1	39·87	139·5
Highest over period			17·4	0·5	12·50	3·00	28·4	48·3	42·6	150·6
Lowest over period			12·2	—	9·10	2·10	24·8	41·6	37·4	130·1

TABLE IV.—TEST OF GAS ENGINE AND GENERATOR.

Engine Set Number.	Load Factor.	Load.	Generator.		Load.	Gas Engine.		Calorific Value of Gas per Cub. Ft.
			Gas per Kw.-Hr.	Heat per Kw.-Hr.		Gas per B.h.p.-Hr.	Heat per B.h.p.-Hr.	
	per cent.	kw.	cub. ft.	therms.	b.h.p.	cub. ft.	therms.	therms.
12	102	350	93·57	13,062	510	64·24	8,968	139·6
11	84	285	102·00	13,759	420	69·5	9,368	134·79

TABLE V.—TESTS OF EXHAUST BOILERS USING THE EXHAUST GASES FROM A 500 BRAKE HORSE-POWER "PREMIER" GAS ENGINE.

Engine Set, Number.	Load.	Heating Surface.			Steam Pressure.	Evaporation per B.h.p.-Hour.		Temperature of Exhaust Gases.			Load Factor.
		In Boiler.	In Water Heater.	Total per B.h.p.		Actual.	From and at 212 Deg. F.	Entering Boiler.	Leaving Boiler.	Leaving Heater.	
	b.h.p.	sq. ft.	sq. ft.	sq. ft.	lb. per sq. ft.	lb.	lb.	deg. C.	deg. C.	deg. C.	per cent.
9	471	523	None	1·05	53·7	1·91	2·16	560	291	—	94
11	420	523	57·5	1·16	43·0	2·15	2·5	477	198	180	84

TABLE VI.—SULPHATE OF AMMONIA.

Average amount recovered per week on standard basis, 24·5 per cent. NH_3.

Weeks.	Coal Gasified.	Sulph. Am. Recovered.	Sulph. Am. per Ton of Coal.	Nitrogen in Coal.	NH_3 Recovered.	Actual NH_3 in Sulph. Am.
	tons.	tons.	lb.	per cent.	per cent.	per cent.
26	134·3	5·21	87·0	1·285	64·2	25·29
13	150·1	6·11	91·03	1·32	65·6	25·39

TABLE VIII.—POWER-PLANT RUNNING COSTS PER KILOWATT-HOUR, SIX MONTHS, 1918. INCLUDING CREDIT FOR SALE OF SULPHATE OF AMMONIA AND DEBITING COST OF SULPHURIC ACID.

	Per Ton. £ s. d.
Average price of coal	1 8 11
Average price of sulphuric acid	4 13 0
Average price of sulphate of ammonia	17 2 0

Units from Switchboard.	Fuel.	Lubrication.	Supervision and Labour.	Repairs and Renewals.	Charges on Capital, 10 per Cent.	Total.	Load Factor.
	d.	d.	d.	d.	d.	d.	per cent.
1,834,375	0·166	0·058	0·159	0·130	0·207	0·720	73·6

best to shut the tar off and to run on coal only, keeping the tar for such times as a good coal fire can also be maintained, which not only protects the fire-bars from the blast action of the tar jet but also facilitates the consumption of smoke. In this way the tar can be burned without smoke, but it requires watching. If the grates are allowed to run bare, and the tar jet deflected downwards, the grate bars may very readily be damaged.

Before deciding to burn it the question of distilling the tar was considered. A mixed sample was obtained and an analysis made, with the following result :—

	Per Cent.
Moisture	7·0
Crude oils up to 170 deg. C	2·6
Creosote between 170 deg. to 190 deg. C.	17·5
Creosote between 190 deg. C. to pitch	7·8
Pitch	65·1

On going into the question of distilling plant it was found that the cost of the same, and the labour in connection therewith, would not warrant its installation in view of the comparatively small amount of oil that would be recovered. The tar which comes off in No. 4 washer and the centrifugal cleaner undoubtedly contains more oils, but the quantity obtained is too small for distilling commercially.

Power-Plant Running Costs.—Table VIII gives the cost per unit taken from the actual cost sheets for six months in 1918, including 10 per cent. on the capital outlay.

The lubrication costs are rather high, due to the fact that at the period covered a system of forced lubrication was in use on two of the gas engines. Since then the arrangements have been altered and now the consumption of oil for lubrication on the gas engines has been reduced by 46 per cent.

The costs include the value of the current used in running the gas plant and auxiliaries which, during six months, amounted to approximately 8·5 per cent. of the units generated. As, however, only about 42 per cent. of the gas made was used for the gas engines the actual amount of current required for auxiliaries represents only 3·6 per cent. of the current that would be generated if all the gas were used for that purpose.

The cost of the fuel if the above debit had not been made would be 0·160*d.* per unit, a difference of 0·006*d.* or 3·6 per cent.

NOTES ON OPERATING.

Producers.—These have worked very well, and although minor difficulties occurred during the first few months they have been overcome. The chief difficulty was due to the small coal and dust at first used. It was found that the circular overhead coal pockets and the cone valve on the feed hopper tended to separate the coal so that dust went to one side and the larger pieces to the other side of the producer, consequently the fuel burned unevenly and the side on which the larger fuel fell got much hotter due to the lesser resistance and freer passage for the air and steam.

In this connection it must also be borne in mind that all the stokers had to be trained from the beginning, and owing to the shortage of labour following mobilisation no skilled stokers were available to give them the usual training. For a novice to handle a big producer with the long heavy pokers is strenuous work, but the difficulties were tackled very willingly and soon overcome, to such an extent that they were kept under until such time as regular deliveries of coal were made, when they disappeared.

Washer Tanks.—The circulating tanks are provided with sloping bottoms so that the tar which settles in the water can run down and be drawn off when necessary. For Nos. 3 and 4 washers this worked very well, but with No. 2 the tar was sometimes too thick to run easily, and in No. 1 tank the amount of tar was usually small but mixed with a large proportion of dust and soot which blocked the tar outlets.

The usual perforated scoops were provided for skimming the tar which floats off the surface of the water in the tanks. The use of them involved a good deal of labour and led to the development on the works of a better method. A sloping plate was fitted to the edge of the tanks at about an angle of 45 deg. and dipping about 6 in. into the water. By using a flat scraper it was then possible to skim the tar off much more quickly and with less exertion.

Details of this kind appear insignificant, but they make all the difference to the cleanliness and comfort in which the work can be carried on.

Corrosion.—In spite of the success which followed Mr. Lymn's use of non-lead lined steel vessels elsewhere, some anxiety was felt as to the result in this case and careful watch was kept, inspection being made whenever opportunity offered.

The reason why corrosion takes place in some cases and not in others does not yet appear to have been discovered, although many attempts have been made to solve the problem by chemists engaged on recovery plants. Apparently the composition of the coal has something to do with the matter. From the author's experience it would appear that when using mild steel plates very little corrosion takes place, unless the metal is also subject to either erosive action or is under stress. At such points corrosion may be rapid.

In the case of Messrs. Hoffmann's plant, ammonia recovery was not attempted until some weeks after the plant was started, in order that the interior of the vessel might get thoroughly coated with tar before any acid liquors were circulated. Beyond the failure of a few bolts and rivets there has been no trouble from corrosion.

Centrifugal Fan Cleaners.—These do their work well but too much is expected of them. The design of the fan is such that the tar and water driven out of the gas by centrifugal force are not thrown off clear but have to run down the casing and through the outlet with the gas before draining away, consequently the gas is liable to pick up some tar again.

A modification of the design which would allow the tar and water to get away from the system immediately it had been thrown out of the gas would make the machine more effective.

The action of the water in the tar fans is mechanical and, under present conditions, cold water is necessary to reduce the temperature of the gas and to condense the tar into such vehicles that it can be caught by, and separated out with, the water. If the washing water is cooled in towers the possible temperature of the return water is not really low enough to be thoroughly effective, so fresh cold water has to be brought into circuit and dirty hot water thrown away. The effluent, when handled in a coke filter, can be made perfectly satisfactory, but it leaves behind a tar laden by-product which is difficult to dig out of the filter beds and difficult to burn because it is saturated with water and coated with tar.

Sawdust Scrubbers.—In town or coke-oven gas works scrubbers packed with iron oxide are used, the action of which is chemical rather than mechanical, and the spent oxide residue has a trade value.

When sawdust scrubbers are used their function is purely mechanical. The removal of the tar-laden sawdust is an objectionable process and the dirty material is difficult to dispose of. Increasing the number of scrubbers only enables any box to run longer, as it decreases the rate at which the gas passes through it, and thus only postpones the dirty day. The final traces of tar are due to the lighter tars with low condensing temperatures, and it is therefore highly important to reduce the temperature of the gas before it reaches the scrubbers.

This all points, in the author's opinion, to the advisability of getting the gas temperatures down lower and catching the tar as pure as possible and free from sawdust, or coke filtering processes.

The P. and A. and various centrifugal types of machines have been used for town and coke-oven gas, but are not so successful on producer gas. It is hoped that the demand will justify research and experiments in this field, and will develop an apparatus which will be light in cost of operation and maintenance.

Electrostatic System of Gas Cleaning.—Having in mind some experiments conducted by Sir Oliver Lodge in 1905, in connection with fog dissipation, which, although quite successful on a laboratory scale, were found too costly to apply to a London fog, the author thought that something might have been done in this direction.

Sir Oliver seems to have first introduced the system to the public at Montreal in 1884.* Sir Oliver there showed experiments with magnesium smoke in glass globes fitted with points of wire connected to an electrical plate machine. When the current was turned on, it is stated that the smoke and dust crystallised or

* *Electrician*, September 27, 1884.

solidified into filaments and streamers on the points of the wire.

The Cottrell system was tried at the Ann Arbor Town gas works,* but the trouble in keeping the electrodes insulated appears to have prevented a more general application of the system and, so far as the author has been able to ascertain, it has not been applied to producer gas.

The Steere Engineering Company of Detroit have also used static electricity. In their case the current employed was alternating.

Although these systems have been highly successful in connection with the precipitation of dust in the smelting and cement industries there appears to be difficulty when applied to gas cleaning in keeping the electrodes free from tar deposit.

A recent application to Sir Oliver Lodge drew from the Lodge Fume Company the statement that they are working on the matter in this country, but it is too early yet to say anything definite about it.

Circulating Pumps and Pipes.—Owing to the comparatively small quantity of water circulated round the washers, 200 gallons per minute, the pumps are small and light. It was found that small pieces of wood, and small stones mixed with tar and dust, collected in the casings which, in larger pumps, would have been carried through. Pumps for this purpose should have outside bearings and a flexible coupling to the motor; the glands should be ample in size for flexible packing and easily adjustable.

The delivery and suction pipes should be arranged as short as possible, since the efficiency of the cleaning plant depends entirely on them and may be greatly reduced by a deposit of tar.

Cast-iron pumps were used for circulating the sulphate liquor on account of the difficulty in obtaining bronze. After running about six months these began to give trouble due to corrosion by the acid, particularly round the chaplets. Attempts were made to repair them, but after the armistice it was decided to replace them with bronze pumps.

Gas Mains.—These are fitted with dust outlets and poke holes which enable the attendant to keep the pipes clear while the plant is in operation. This is not difficult when running continuously. It was found, however that due to the week-end stoppage there was a tendency for the inlet to No. 1 washer to get blocked, and also the bottom of the down-comer from No. 1 washer. Additional poke holes were provided at the inlet and a water-luted outlet was fitted to the down-comer.

In the second plant the bottom of the down-comer has an open end dipping into a lute, which prevents any accumulation of dust in the main at this point.

It is not necessary to clean out the gas mains except at the usual holiday stops during the year, viz., Easter, August and Christmas, when all the extra cleaning necessary can be effected.

Temperature and Pressures.—Fig. 4 shows the air and gas temperatures and pressures at important points from the blower through the producers to the gas leaving the works.

It will be noticed that as far as possible the gas pressures both positive and negative, are kept low. The greatest variation is before and after the centrifugal blowers. This cannot be avoided if the gas is to be delivered at a reasonable pressure to the works.

In the "Mond" plants it is customary to keep the pressures always above atmosphere. The disadvantage is the increased pressure at the producer and washers which leads to loss of gas due to leakage, also some discomfort for the men working the plant, particularly those who have to poke and keep the producer fires in good order.

GENERAL REMARKS.

After all that has been heard recently concerning the efficiency of electric power stations it is interesting to compare the figures with those of Messrs. Hoffmann's plant which, for the six months period quoted above (Table II) consumed 1·51 lb. of coal per unit and show a thermal efficiency of 19·9 per cent, on the units delivered to the feeders.

Mr. David Wilson (Technical Adviser to the Controller of Coal Mines) gave figures for the year ending March, 1918, at a meeting of the Junior Institution of Engineers, February 27, 1919.

—	Output in Units.	—	Coal per Unit.	Thermal Efficiency.
			lb.	per cent.
A	200,000,000	Stations in the South of England	2·53	10·88
B	40,000,000		2·32	13·05
C	22,000,000		2·49	11·95
D	200,000,000	Stations in other parts of the country	2·78	10·83
E	46,000,000		2·40	12·35
F	28,000,000		2·40	12·15

Subsequently published figures show that the eight stations in the Northumberland district in the year ending March, 1919, generated 272·8 million units at an average consumption of 2·40 lb. of coal per unit generated. The best station in that district shows a coal consumption of 1·80 lb. per unit and a thermal efficiency of 18 per cent. on the units generated.

The next district in order of merit is Durham with 13 stations generating 307·8 million units and an average consumption of 2·56 lb. of coal per unit, with a best single station consumption of 2·2 lb. per unit and a thermal efficiency of 15·2 per cent.

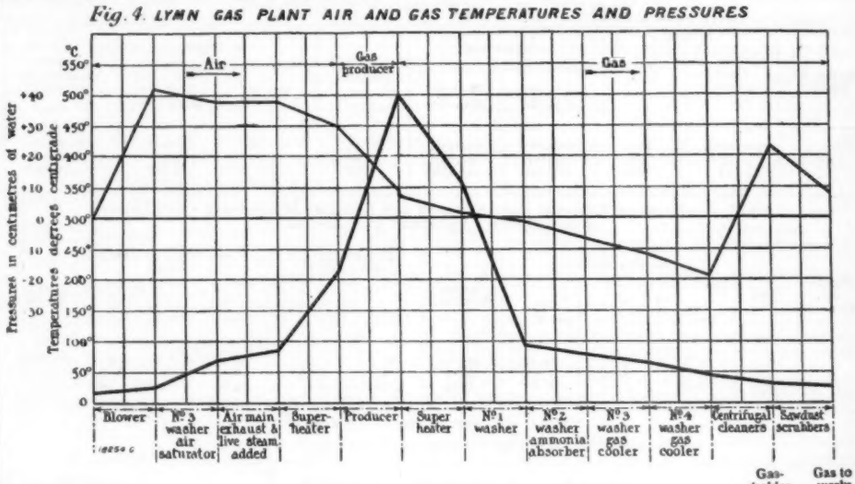
Taking the whole of the 438 stations included in the returns, the units generated amounted to 4,623 millions with an average consumption of 3·46 lb. of coal per unit. The calorific value of the coal is not available but, assuming 11,000 therms per pound, the thermal efficiency would be 9 per cent.

The Detroit Edison Company's figures which, by the kindness of Mr. Alex. Dow, the author had the pleasure of sending to the *Electrician* in June last,* show a coal consumption per unit delivered to the feeders and a thermal efficiency for the six months' periods from June, 1916, to December, 1918, varying from 1·44 lb. and 17·33 per cent. efficiency, to 1·63 lb. and 16·33 per cent. efficiency.

When comparing the capital cost of this plant with other costs it is important to note that, while the four producers are of large size, the gas washing and recovery plant is made up of eight vessels, the total cost of which is much greater than it would be if the plant had been put down at one time as a 60-ton plant instead of as two 30-ton plants. Four vessels would then have sufficed which would not have been much heavier than four of the present vessels, and the consequent saving in pipe-work, foundations, and auxiliaries would have been very considerable.

As regards the use of gas engines, experience here as well as elsewhere has proved that they are reliable and, where gas is available—whether it is used for boiler firing or used direct in engines—will be determined largely by the size of the plant contemplated.

Fig. 4. LYMN GAS PLANT AIR AND GAS TEMPERATURES AND PRESSURES



In the author's opinion the large cylinder high-power gas engine will be developed in this country as it has been abroad. He is a firm believer in the quick-revolution steam engine up to a size, but it has its limitations which have been masked by the development of the turbine. If large gas-engine units are called for, as they surely will be, in greater numbers it does not appear likely that a multiplicity of small cylinders will answer the call. If a 3,000 h.p. unit can be safely developed on four cylinders, why use 24 cylinders? Meantime the gas turbine is not a commercial product.

For huge plants the steam turbine has no competitor, and the opportunities for combining such a plant complete with by-product recovery from fuel cannot be frequent, so it is more probable that in such plants direct coal-firing will be the rule, assisted, to a small extent, by surplus gas-fied boilers as has been at present attempted.

Power is a necessity. Coal is a wasting asset and, while the engineer is anxious to convert coal into power, thermal efficiency must not outweigh all other considerations or be allowed to become a fetish.

The country needs power but it finds other products from coal necessary, and no amount of "cheap power" will take their place. Whether power (as electricity or gas), tar derivatives, or coke, is the by-product, can only be determined by consideration of the coal and the locality in which it is produced.

In dealing with fuel problems the first question to settle is, which is to be the product and which the by-products? Coke, gas, oil, ammonia, &c., present a large variety of alternatives for choice. The price and quality of the fuel, the cost of the plant, the cost of operating, and the possibility of disposing of the by-products at remunerative rates are all factors in arriving at the cost of the product. A comprehensive view of the situation is necessary.

We have only two minerals to export, coal and China clay, and we must make the most of them, exporting only the best at the best prices. The position of the industrial centres of manufacture has always been settled by the position of the potential power supply, in our case by our coalfields, and it seems at any rate a debatable question whether the country can be reconstructed on such a plan that natural advantages are of small account.

It is absolutely certain that low-grade fuel must be better utilised in the future than in the past. This should be used locally to save the cost of carriage. Any attempts to use such fuel have generally been abandoned in favour of high-grade fuel, whether for boiler-firing or for producer-gas plants. It is said to have been done for economy. Whether the altered conditions under which we shall have to carry on in the future will permit it is an open question; the factors which have to be considered in economy are rapidly changing in values.

For burning low-grade fuel an arrangement of a grate external to the boiler would be better than a grate directly under the boiler, as the grate need not be so restricted, and the next step is a producer grate. Siemens developed the circular producer for furnace work forty years ago on much the same lines.

Calculations have been made showing the loss in producer gas firing of boilers, with and without by-product recovery, as compared with direct coal-firing, but these questions are not always settled by calculation. There are many variables and unknown quantities. Both the gasification and carbonisation of coal have been much discussed in connection with the fuel economy campaign.

It is not all coal that will coke, nor is there an unlimited demand for coke. If there was such a demand the fact that coke is twice as bulky as the coal from which it is made would severely handicap its transport, which points to its being used locally. It must be admitted that there is no more likelihood of all coal being gasified than of it all being coked, but there is every probability of much more coal undergoing one or other of these processes than at present.

Low-temperature carbonisation has no special therapeutic effect, and although in some quarters much is expected of it the industry still has to be established on a sound commercial basis. The semi-coke offers a pleasanter fuel for domestic hearths as an alternative to gas coke, but it is not likely to displace furnace or foundry coke. Low-temperature carbonisation will not make good semi-coke out of rubbish, any more than a high-temperature process will make good coke of it, and it remains either to wash all the dirt possible out of low-grade fuel or to burn it with a high-ash content.

To wash coals costs money and is only in part effective, while to burn rubbish calls for more labour in transport and handling, larger grates, and more heat is thrown away in the ash. The same considerations apply, no matter whether the burning is done in a producer or in a steam boiler.

To what extent sulphate of ammonia recovery from fuel will pay will depend not only on the nitrogen content of the fuel and its price, and the cost of recovery including capital charges, but also on the selling price of the sulphate, and this may be greatly affected by some of the processes of nitrogen fixation which have been so largely developed during the war. This last consideration is likely to have an important bearing on the adoption of an ammonia-recovery process from coal.

Again, we have an at present only partly explored field in the application of pulverised fuel. The high boiler efficiency, due to the possible close regulation of air, is attractive but is not assured, and if obtained may be too dearly bought when the cost of pulverising and the trouble from dust and clinker is emphasised, as it is in the case of fuel with a high ash content.

A most disturbing element at the present time is the shortened week with only one operating shift. This is perhaps not the place to discuss its effect on the country, but we are certainly justified in stating here that load factor is the important element in cheap power, and a high load factor is impossible with a short working week and only one shift worked in the 24 hours. Such operating cuts at the root of economical power stations, and even if we supply over large areas this will not give a diversity factor to make up for the short working hours of the consumers. If manufacturing calls for cheap power it must remember that a low price depends on long hours of operating and a high load factor.

In conclusion the author desires to put on record his indebtedness to the managing directors of the Hoffmann Manufacturing Company for permission to publish these particulars of their plant, also to their staff and his own, and to Mr. A. M. Lymn, for their ready assistance rendered in the matter.

* *American Gas Light Journal*, September 21, 1914.

* *Electrician*, 1919, vol. lxxxii, page 702.